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Devoted Primarily to the Scientific Study of Problems of Learning and Teaching.

HAROLD RUGG, *Editor*

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CONTENTS

ONE MORE STUDY OF PERMANENCE OF INTEREST. *Harvey C. Lehman and Paul A. Witty* 481

MIRROR READING AS A METHOD OF ANALYZING FACTORS INVOLVED IN WORD PERCEPTION. *Miles A. Tinker and Florence L. Goodenough* 493

THE RETENTION OF MIRROR-READING ABILITY AFTER TWO YEARS. *Florence L. Goodenough and Miles A. Tinker* 503

VOCATIONAL INTERESTS AND TYPES OF ABILITY. *Ralph H. Gundlach and Elizabeth Gerum* 505

A VOCABULARY STUDY OF BIOLOGY NOTEBOOKS OF FIFTY REPRESENTATIVE SECONDARY SCHOOLS IN NEW YORK STATE. *Don O. Baird* 512

MECHANICAL "APTITUDE" OR MECHANICAL "ABILITY"?—A STUDY IN METHOD. *O. L. Harvey* 517

THE RELATIVE EFFORT OF CHILDREN OF NATIVE *vs.* FOREIGN BORN PARENTS. *S. Edson Haven* 523

THE EFFECT OF THE FORM OF A COMBINATION IN THE LEARNING OF A MULTIPLICATION TABLE BY BRIGHT AND DULL CHILDREN. *F. T. Wilson* 536

STUDY HABITS OF TEACHERS COLLEGE STUDENTS. *Hugh M. Bell* 538

CONSTANT CHANGES IN THE STANFORD-BINET IQ. *Psyche Cattell* 544

SOME RELATIONSHIPS BETWEEN ALGEBRA AND GEOMETRY. *Dorris May Lee and J. Murray Lee* 551

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An Experimental Study of Certain Factors Affecting
Transfer of Training in Arithmetic
By JAMES ROBERT OVERMAN

The investigation here reported was planned to study the effect of instruction on three types of examples in two-place addition upon the pupils' ability to handle closely related types in addition and subtraction, and to determine whether the amount of transfer is a function of the method of teaching.

The problem was to ascertain if the amount of such transfer can be increased by helping the pupils consciously to generalize the process and to formulate, from the types taught, a general method of procedure applicable to related types.

An introductory chapter summarizes briefly previous experiments in the transfer of training and shows the changes that have occurred in the attitude of psychologists toward this question within the last thirty-five years.

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THE JOURNAL OF
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Volume XXII October, 1931 Number 7

ONE MORE STUDY OF PERMANENCE OF INTEREST*

HARVEY C. LEHMAN

Ohio University

AND

PAUL A. WITTY

Northwestern University

The question of permanence of vocational interest is obviously of utmost importance to those concerned with problems of personnel and guidance. If guidance be based upon a pupil's assumed occupational interest, and if this assumed interest proves subsequently to have been merely a passing fancy or a temporary whim, the outcome of course will be wasteful and the practice injudicious. Obviously the question of the degree of permanence of interest is one of great individual and social significance.

In order to ascertain the extent and degree of permanence of vocational interest, the writers administered the Lehman Vocational Attitude Quiz to a large number of school children in Topeka, Kansas, and in Kansas City, Missouri.†

The Vocational Attitude Quiz consists of a comprehensive and catholic list of two hundred occupations. First, the children are asked to check *only* those occupations in which they are willing to engage as life work. They are then asked to indicate: (1) The three occupations which they would like best to follow, (2) the one occupation which they most likely will follow, (3) the three occupations which

* The present study presents some findings that have been made possible by a grant-in-aid from the Social Science Research Council.

† The writers are indebted to Miss Anna G. Myers, Mr. J. F. Kaho, Superintendent A. J. Stout, and Superintendent George A. Melcher for assistance in securing these data.

they think are the best money-makers, (4) the three occupations which they believe are most respected, and (5) the three occupations which they believe will require the least amount of effort. The number of children from whom data were obtained is indicated in Table I.

TABLE I.—TOTAL NUMBER OF CHILDREN INCLUDED IN A SERIES OF INVESTIGATIONS OF CHILDREN'S VOCATIONAL ATTITUDES

Ages	Topeka, October, 1927		Topeka, May, 1928		Kansas City, November, 1928 (superior economic status)		Kansas City, November, 1928 (inferior economic status)		Kansas City, November, 1928 (average economic status)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
8½	203	259	82	101	137	180	140	174	304	324
9½	349	358	257	274	212	211	182	203	342	359
10½	403	372	347	340	261	238	236	222	430	435
11½	387	375	385	355	259	272	253	228	356	377
12½	392	372	429	337	331	326	269	266	313	332
13½	365	346	363	378	373	317	235	222	252	298
14½	361	391	352	329	291	345	166	164	246	282
15½	324	322	285	343	294	305	132	181	209	241
16½	251	299	239	261	248	217	93	95	172	197
17½	162	156	160	171	132	111	46	37	106	95
18½	57	36	69	44	48	33	13	7	43	19
Totals..	3254	3286	2968	2933	2586	2555	1765	1799	2773	2959

Total boys	13,346
Total girls	13,532
Grand total	26,878

Table II presents the order of merit (rank frequency) of occupations in which boys 8½ to 18½ years of age stated that they *would be willing to engage.* Table III presents the rank of occupations *liked best or preferred most* by the boys 8½ to 18½ years of age.

Table II is to be read as follows: "Aviator" is the one occupation that was most frequently checked by boys of 11½ to 18½ years of age as the occupation in which they would be willing to engage as a life work. This activity ranked sixth for boys 8½, third for the boys 9½ years of age, and second for the boys of 10½ years of age. A blank

space in the table indicates that the particular occupation was mentioned by an exceedingly small percentage of pupils, and a rank therefore was not assigned. Tables II and III show the rank only of the most frequently mentioned occupations for each age group.

TABLE II.—RANK IN FREQUENCY OF OCCUPATIONS IN WHICH BOYS OF 8½ TO 18½ YEARS OF AGE WOULD BE WILLING TO ENGAGE

No.	Occupations	Ages										
		8½	9½	10½	11½	12½	13½	14½	15½	16½	17½	18½
66	Aviator	6	3	2	1	1	1	1	1	1	1	1
81	Civil engineer	..	28	22	18	10	5	3	1	2	4	2
18	Architect	..	..	..	38	27	16	7	4	3	3	3
83	Electrician or electrical engineer	..	..	37	28	18	12	6	3	4	2	4
100	Cowboy	1	1	1	2	2	2	11	33	35		
36	Sailor	2	5	3	5	7	15	21	29	38		
33	Army officer	3	2	6	4	5	8	17	16	15	18	13
34	Soldier	4	4	4	9	14	22	39				
110	Sheriff or policeman	5	7	10	12	23	34					
70	Professional baseball player	7	6	5	3	3	4	5	11	11	12	20
67	Jockey or automobile racer	8	8	8	7	8	13	14	18	19	25	27
22	Ship builder	9	14	16	23	33						
74	Fireman or engineer on a train	10	9	9	10	13	11	16	19	29	34	
102	Fisherman, hunter, or trapper	11	11	13	13	15	18	15	23	26	29	
76	Fireman (answering fire alarms)	12	12	19	23	34						
6	Banker	14	13	14	17	17	14	12	7	6	7	8
35	Naval officer	13	10	7	6	6	6	9	8	10	11	16
3	Lawyer	15	18	21	21	21	20	18	12	8	5	5
69	Professional boxer or wrestler	16	15	15	15	20	21	25	34	39		
68	Physical director or athletic coach	..	..	42	33	29	27	26	20	17	18	6
52	Musician	39	43	33	27	26	23	19	19	24	17	8
65	Radio expert	20	23	23	22	19	19	10	9	11	8	9
26	Automobile dealer	24	17	26	24	28	30	28	25	21	18	10
103	Explorer	..	31	20	19	16	17	13	13	9	9	9
107	Forest ranger or woodsman	42	25	18	14	12	7	4	6	5	6	11
108	Detective or secret service work	31	22	12	8	4	3	2	5	7	7	15
91	Stockraiser or ranchman	25	14	11	11	11	9	8	14	13	20	19
80	Chemist or chemical engineer	..	..	..	..	32	24	20	17	16	13	10
10	Buyer for a large store	..	..	..	..	..	28	33	21	12	15	7
136	Confectioner	18	33	41								
109	Night watchman	17	29	43								

Those of equal frequency are given the same rank but, contrary to the usual custom, ranks are omitted in instances in which few or no boys checked the occupation.

Certain of the frequency ranks change markedly with advance in chronological age. For example, in Table II the third item from the top of the list is "Architect." This occupation was rarely checked

by young children, but at ages 16½ to 18½, it was checked frequently and therefore received rank three.

In Table III, the second item is "Cowboy." This occupation receives rank one at ages 8½ and 9½. At the upper age levels of course this occupation ranks very low. The findings for this occupa-

TABLE III.—RANK IN FREQUENCY OF OCCUPATIONS LIKED BEST BY BOYS OF 8½ TO 18½ YEARS OF AGE

No.	Occupations	Ages										
		8½	9½	10½	11½	12½	13½	14½	15½	16½	17½	18½
66	Aviator	2	2	1	1	1	1	1	1	1	1	1
100	Cowboy	1	1	2	2	2	5	16				
3	Lawyer	6	7	10	6	7	6	10	5	4	2	3
81	Civil engineer		16	8	9	3	2	2	2	3	3	7
2	Doctor (physician, surgeon or specialist)	11	13	10	11	11	11	11	7	6	9	6
33	Army officer	4	3	3	4	6	15	24	12	21	13	8
70	Professional baseball player	9	6	5	3	4	4	5	9	10	12	11
6	Banker	7	9	12	15	14	13	13	6	7	10	10
53	Musician	20	15	14	16	10	12	7	8	9	6	5
35	Naval officer	12	10	9	5	9	13	14	15	18	15	10
83	Electrician or electrical engineer	..	..	20	22	5	3	3	3	2	4	4
18	Architect	..	..	..	..	17	10	4	4	5	5	2
68	Physical director or athletic coach	..	..	..	..	..	24	23	12	11	11	4
41	Movie actor	17	11	18	18	16	16	19	13	19	19	13
74	Fireman or engineer on a train	8	7	7	7	9	7	9	17	12		
34	Soldier	3	4	4	12	20	30					
110	Sheriff or policeman	10	14	15								
36	Sailor	5	5	6	8	15	21	20				
67	Jockey or automobile racer	13	8	9	13	13	17					
108	Detective or secret service work	..	..	13	10	8	9	8	11	14	15	
14	Newspaper work	..	..	..	..	..	..	25	18	14	14	7
107	Forest ranger or woodsman	..	..	20	19	13	8	6	10	8	17	13
65	Radio expert	..	..	..	..	23	23	15	19	19	21	11
90	Farmer, miscellaneous	..	16	17	20	19	18	19				
91	Stockraiser or ranchman	..	..	16	14	12	14	12	14	11		
69	Professional boxer or wrestler	..	..	19	17	22	25	36				
84	Mechanical engineer	..	..	..	..	..	..	..	..	..	7	
80	Chemist or chemical engineer	..	..	..	..	..	..	..	..	..	8	

tion are portrayed clearly in Fig. 1 and Table IV which present the percentage of five groups of white boys of various ages who asserted that they would be willing to become cowboys. It will be noted from Fig. 1 and Table IV that the ranks are relatively consistent at the several early age levels. Nevertheless, it is clear also that permanence of interest in this particular vocation is decidedly lacking.

The writers have assembled, similarly, data for all the occupations of the check-list which were reported by the children as ones which they would be willing to enter. At age 8½ the average number checked by the boys was 23.3; at age 18½, the average was 15.6. Since the number of occupations in which boys may engage is exceedingly large, the percentages for each of the many occupations are

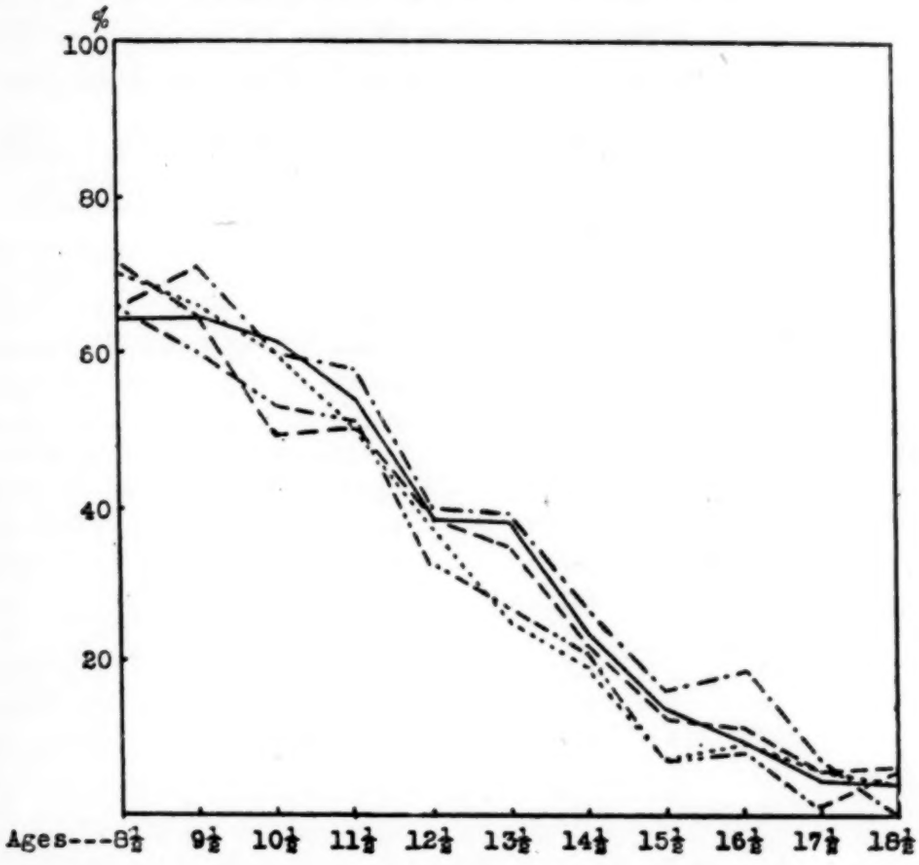

FIG. 1.—Per cents of five groups of white boys of various age levels who expressed willingness to become "Cowboys."

———— Topeka, Oct., 1927
———— Topeka, May, 1928
———— Kansas City, Mo., Nov., 1928 (Superior economic status)
———— Kansas City, Mo., Nov., 1928 (Inferior economic status)
———— Kansas City, Mo., Nov., 1928 (Average economic status)

small. Because of this fact, the data showing percentages for each age level do not portray vividly the striking changes in attitudes that really take place from year to year. A careful study of the data suggests however that permanence of interest does not exist in many or even most of the vocational preferences of boys. Indeed, from examination of the ranks of the occupations at different age levels, the writers have been forced to conclude that perhaps no phase of

human nature is subject to such marked change as that reflected in the vocational interests and preferences of growing boys. This conclusion differs strikingly from that expressed by numerous workers of the past and by several present-day ones.

Among the earliest studies of permanence of interest were those of Thorndike.[1] Thorndike concluded that it would be hard to find "any feature of a human being which was a much more permanent fact of his nature than his relative degrees of interest in different lines of thought and action." (P. 456.)[1] He concluded also that

TABLE IV.—PERCENTAGE OF FIVE GROUPS OF WHITE BOYS OF VARIOUS AGE LEVELS WHO EXPRESSED WILLINGNESS TO BECOME "COWBOYS"

Ages	Topeka, October, 1927	Topeka, May, 1928	Kansas City, November, 1928 (superior economic status)	Kansas City, November, 1928 (inferior economic status)	Kansas City, November, 1928 (average economic status)
8½	64	71	66	66	70
9½	64	64	59	71	66
10½	61	49	53	60	60
11½	54	50	51	58	50
12½	38	40	33	40	37
13½	38	35	27	39	25
14½	24	22	21	26	19
15½	14	13	7	16	7
16½	10	12	8	18	10
17½	5	6	1	7	6
18½	4	7	6	0	5

interest and ability are so closely bound together that "either may be used as a symptom of the other almost as well as for itself." (P. 456.)[1]

Several writers interpreted Thorndike's conclusions as implying that children's vocational ambitions are relatively permanent and that vocational ambition is a suitable index of vocational ability. In 1922, Freyd wrote regarding Thorndike's work: "The methods used were such as to make results of limited significance yet in their field these results are practically all that are available." (P. 244.)[2] Several writers seem to regard Thorndike's former pronouncements and the subsequent generalizations of other writers as valid when they are applied to children today. Moreover, there are many attempts to verify the basic theses. Books and articles are now being published

which present evidence of a continuance of interests for a few months or a single year as proof that such alleged vocational interests are symptomatic of permanent interests. Franklin reports data obtained from some fifteen hundred junior high school pupils of Baltimore who were asked in December, 1922 to name the occupation that they would like best to enter. Follow-up questionnaires were filled out in May, 1923, October, 1923, and December, 1923. The following conclusions were expressed.

> The vocational interests of junior high school pupils show a very high degree of permanence over a period of at least one year,—and that a very critical one. Two children out of every three have the same preference at the end of the period as they had at the beginning. (P. 155.)[3]

McCracken and Lamb report a series of studies that were made in Denver March 1, 1920, May 25, 1920, and in April, 1921. The problem of permanence of interest was studied for a period *less than three months in length.*

> Of 4481 junior and senior high-school students whose choices were recorded for March 1, 1920, and May 25, 1920, with the intervening time nearly three months, 73.9 per cent of the boys and 79.5 per cent of the girls chose the same occupation on both occasions.[4]

The credulous reader is informed that "These choices, although made so close together, do indicate some permanency." (P. 43.)[4]

It will be of interest at this point to examine Fig. 1. If the lines of this graph represent the situation as it will exist from year to year it may be asserted that a very large percentage of the boys of a given age who are willing to become cowboys will continue to cling to this notion three months hence,—or even a year hence. To this extent, these data corroborate those of Franklin, and those of McCracken and Lamb. It is clear, however, that *over a longer period of time,* a permanence of interest would not be found. It therefore seems invalid to base conclusions regarding permanence of vocational interest upon a study that continues *only for a few months or for a year.*

The writers have attacked the problem of permanence of interest in a somewhat different manner. They have studied the vocational interests of several thousand children of ages 8½ to 18½. The writers are here assuming that the present 8½-year-old children would respond next year as do the 9½-year-old ones, etc. The validity of this assumption they are at the present time investigating. Several follow-up studies are under way to test the reliability of the children's

reports. Nevertheless, it seems logical to assume that groups of 8½-year-old children will respond next year as do children now 9½ years old provided that the children live in a conservative city, not affected appreciably by a shifting population. If the written expression of willingness (and intention) to enter a given vocation be regarded as expression of interest, it is obvious that many of the interests of the children herein studied cannot be regarded as permanent since many

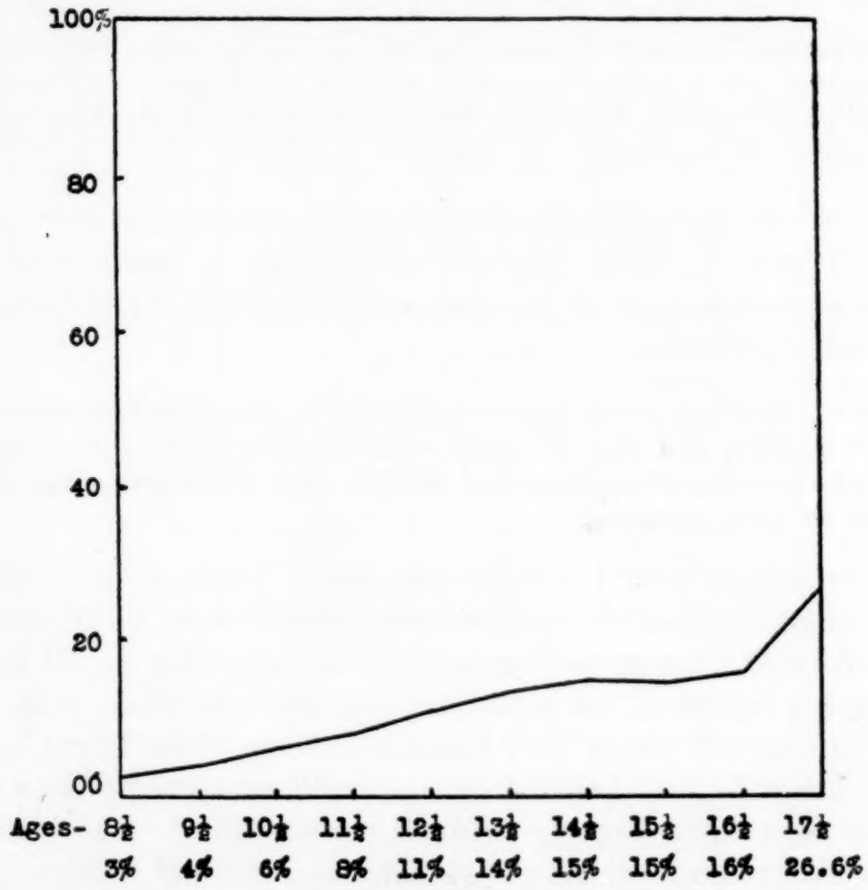

FIG. 2.—Per cents of five groups of boys who stated that they expected to enter one of the following types of engineering: chemical, civil, electrical, mechanical, or mining.

interests of the children change markedly during a period of several years.

It will be of interest to examine the hypothesis that interests are symptomatic of ability. Ability is sometimes conceived as inherent capacity; inborn and unchangeable. If this concept be adhered to, the hypothesis that interests are symptomatic of ability postulates the additional hypothesis that interests do not change markedly. The data herein presented reveal that certain of the children's interests

change markedly during a period of several years. If ability be conceived as inborn and predetermined, it is clear that the children's interests can not be considered reliable indices of their abilities.

Figure 2 shows the percentage of the five groups of boys who stated that *they expected to enter* one of the following forms of engineering: Chemical, civil, electrical, mechanical, and mining. The United States census report shows that in 1920 these five groups of engineers included only 135,789 white persons. According to the census report there were, in the United States in 1920, 29,653,677 white males of ten years of age and above who were gainfully employed. Of this number the five engineering groups listed above comprised less than one-half of one per cent (0.46 per cent). If the ratio between the number of engineers and the total number of other gainfully employed white males continues to remain similar to the 1920 condition, it is clear that no age group can contribute many members to the five engineering groups previously mentioned. Figure 2 shows that 26.6 per cent of the 17½-year-old boys state that *they expect to enter engineering*. Of course one must bear in mind that many of the less competent boys have been eliminated from school by the time age 17½ is reached. It is also well to bear in mind that these are city boys having unusual educational advantages. After due allowance has been made for such facts as these, one can scarcely conceive of the demand for engineers increasing sufficiently to absorb so many youthful aspirants.

The Vocational Attitude Quiz included forty professional endeavors. Figure 3 presents the percentage of the five groups of boys who stated that they *expected to enter* these forty professions. The percentage varies from 24 to 50 at the various ages. According to the U. S. census report, these forty professions included in 1920 only 3.15 per cent of the total number of white males of age ten and above who were gainfully employed. There is of course no valid reason for believing that the 1920 ratio is to exist indefinitely. On the other hand, it is impossible to believe that over fifty per cent of the 14½-year-old boys will have the opportunity to enter the professions. It is more likely that only a small proportion of these boys will be able to find a place in the professions and a still smaller proportion will enter upon the particular profession which at age 14½ they expect to enter.

The situation for the girls of various age levels who stated that they *expected to become stenographers or typists* is similar to that of the boys. Figure 4 shows that over thirty per cent of the 18½-year-old girls

expressed this vocational desire. The U. S. census report shows that in 1920 the white female stenographers and typists (562,664) included only 0.8 per cent of the white female workers (6,962,246) of ages ten and above.

As a pioneer in the field of vocational and educational guidance, Thorndike is entitled to the respect of all. Nevertheless, Thorndike would insist, the writers believe, that his data and conclusions be

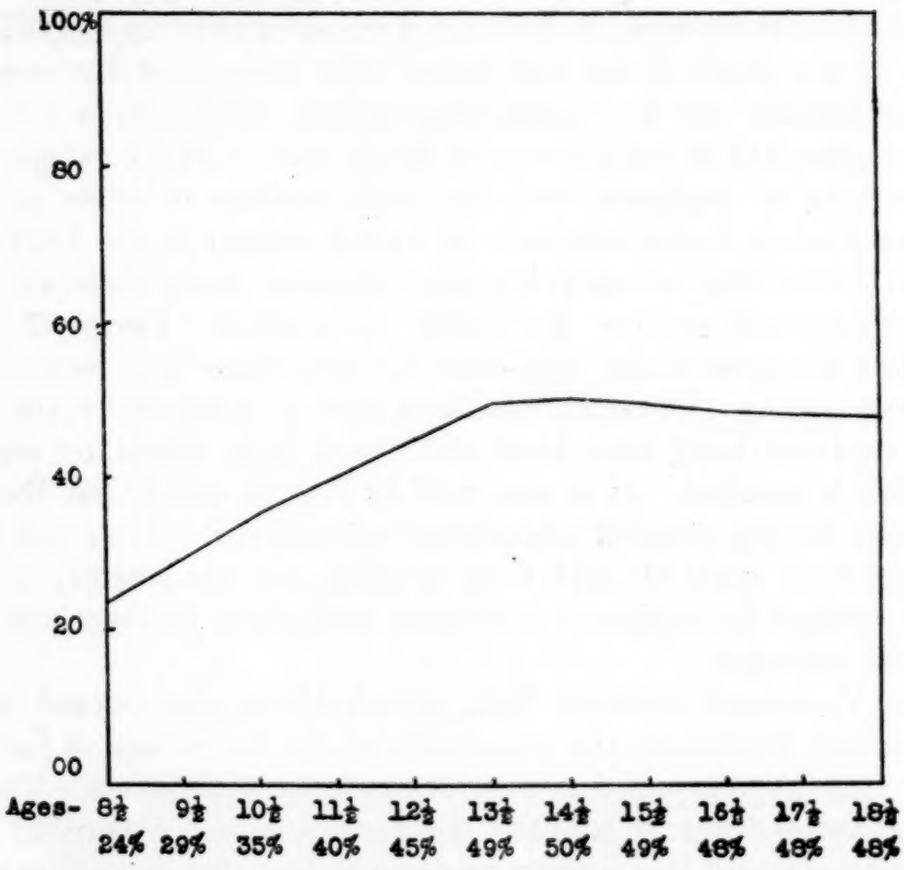

FIG. 3.—Per cents of five groups of boys who stated that they expected to enter one of forty professions.

verified. Certainly, in a country in which social attitudes and values are subject to such reactionary and sporadic fluctuation, it is essential that behavior data be assembled repeatedly to show important trends and socially significant changes. It is, however, difficult for us to modify attitudes which have been generally accepted. Striking indeed is the domination of outgrown, impotent, and socially undesirable determiners of conduct.

The obstacles to psychological advance include not only factors such as inadequate methodology, social taboo, etc. Psychology is

held back also by a serious factor which is not frequently mentioned. Once an error has crept into psychological literature, it often requires the labor of several generations to modify or to dislodge it. At some future date it will be of interest to students of psychology to trace numerous generally accepted present-day misconceptions and rationalizations. At that time it is highly probable that many of the

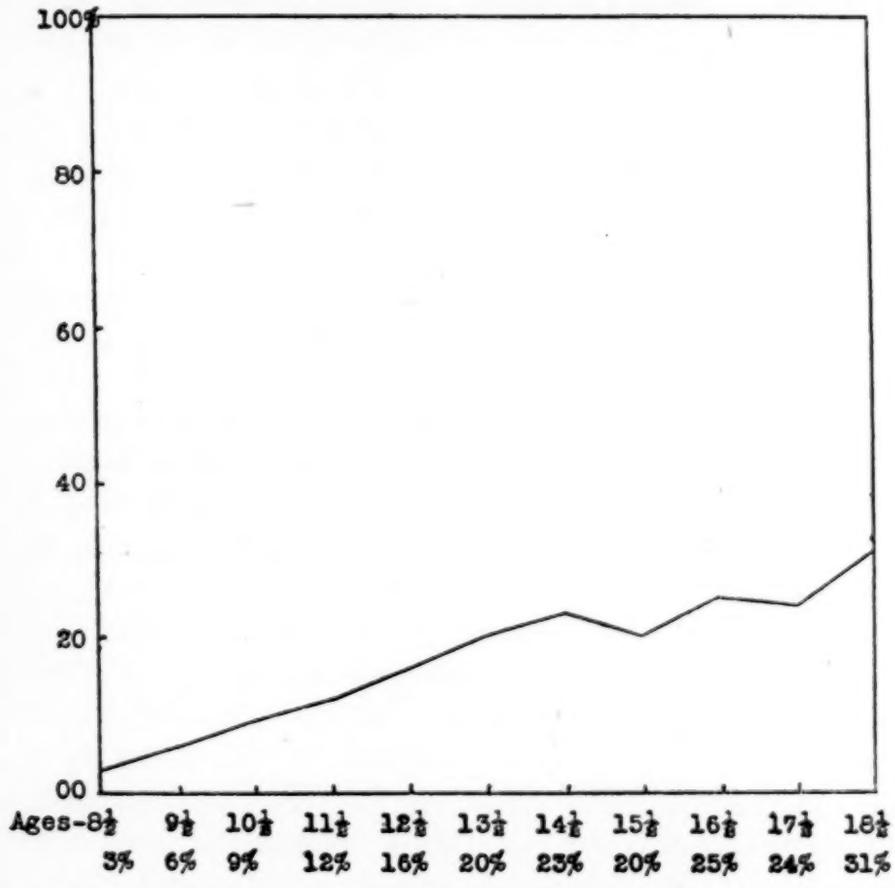

FIG. 4.—Per cents of five groups of girls who stated that they expected to become stenographers or typists.

studies of permanence of vocational interest will be cited as splendid examples of the inadequacy of the retrospective method for identifying interest.

The data assembled by the writers indicate that certain vocational interests cannot be permanent. (See Figs. 2, 3, and 4.) Other interests may be more permanent. And available data show quite clearly that interests are symptomatic of ability only to a limited degree.

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MIRROR READING AS A METHOD OF ANALYZING FACTORS INVOLVED IN WORD PERCEPTION*

MILES A. TINKER AND FLORENCE L. GOODENOUGH

University of Minnesota

This study was undertaken for the purpose of ascertaining to what extent the nature and frequency of the errors made in learning to read aloud English prose material in the reversed position as shown in a mirror might throw light upon the perceptual processes of ordinary reading. Four adult subjects, one man and three women, none of whom had had previous formal experience with mirror reading, participated in the experiment. The subjects worked in pairs, one reading aloud while the other acted as recorder and timekeeper. A rectangular mirror eight by ten inches was used. In the initial stages of the experiment the mirror was held in an upright position by the recorder; but as this was found to be somewhat inconvenient for both persons, a support was devised which held the mirror at a constant angle of one-hundred degrees with the top of the table. Each reader held the book himself and adjusted its distance from the mirror according to his own preference.

In taking the record, the recorder occupied a position facing the reader who held the book with its back towards himself and the pages facing both the mirror and the recorder. In this way the subject was able to read from the mirror, while the recorder followed the text directly and made note of each error as it occurred. A prepared form was used for this purpose. At the end of ten minutes, which was timed with a stop watch, the signal to stop was given and a record was made of the total number of words read and the number of errors made. This included errors which were spontaneously corrected by the subject as well as those which passed unnoticed or at least without correction.

Reading was carried on for ten minutes daily during the period from April 4–July 31. At this time the summer vacation intervened, and practice was suspended until September 25 when it was again resumed and continued until November 1. Save for occasional unavoidable omissions, practice took place seven days a week during these periods.

* Grateful acknowledgment is due to Dr. Mary Shirley who served as subject throughout the experiment, and to Mrs. Eva Tinker who not only acted as subject but is also responsible for the work of tabulating the results.

There was some variation in the time of day at which the reading was done, but as a rule it was carried out during the early part of the evening.

The reading material used during the spring and summer included two detective stories and one novel.* During the fall, approximately half of "Psychology, Its Facts and Principles," by H. L. Hollingworth, was read. The last type of material was better suited to our purpose than were the earlier selections, because of its greater uniformity from page to page. It is probable that of the irregularity in the character of the fiction material used for the first part of the experiment, with its frequent changes from conversation to descriptive matter, accounts at least in part for the irregularity of progress in the early portion of the learning.

Marked individual differences existed among the four subjects in the ability to adapt themselves to the reversed image in mirror reading, and these differences increased rather than decreased with practice. All four subjects showed rapid improvement during the early stages of the learning and very slow gain thereafter. There is a distinct lapse in efficiency upon taking up each new book. This difference is to be attributed chiefly to the large number of new words which were encountered within the early stages of reading a new book, rather than to a change in the typography. The size and style of type was very similar for the four books.

For the entire experimental period the mean number of words read per error was as follows: For Subject No. 1, 138; Subject No. 2, 347; Subject No. 3, 153; and Subject No. 4, 144. With the exception of Subject No. 2, there is but small difference in accuracy among the four readers.

While the foregoing results have some interest for the general subject of learning, the main interest has to do with the nature, frequency and position of the errors made, and the relationship of these

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* In order of reading, the books used were:

1. Gluck, S.: "The Green Blot."
2. Jordan, E. G.: "The Blue Circle."
3. Vance, L. J.: "White Fire."
4. Hollingworth, H. L.: "Psychology: Its Facts and Principles."

The first and third were read completely by all four subjects. Subjects No. 2 and No. 3 read about half of the second book, then substituted "The Closed Book" by J. E. Meyer. Approximately half of this was read. Subjects No. 1 and No. 4 completed the second book without substitution.

factors to word-perception. A summary of the experimental findings to date* reveals some lack of agreement as to the relative importance for perception of total word-form and of the separate elements or letters of which a word is composed; or in other words, whether words are commonly apprehended as configurational wholes or by successive perception of their separate parts or letters. The consensus of opinion, however, seems to be in favor of the former hypothesis. The experimental finding of Cattell,[1] Messmer,[6] Goldscheider and Müller,[3] Erdmann and Dodge,[2] Pillsbury,[7] and others are in conformity with this viewpoint.

Although it seems fairly well demonstrated that practiced readers tend to perceive words as units, rather than as aggregates of smaller elements, the importance of the analytic method in building up these larger perceptual wholes must not be overlooked. The tendency to revert to a method of analysis in terms of single letters or syllables upon encountering a new or difficult word was very evident in all four subjects. This appears to have been the major factor in producing the characteristic drop in the curve at the beginning of each new set of material where a large number of new words were suddenly introduced into the reading vocabulary. The changes were marked, not so much by increase in the total number of errors made, but rather by frequent hesitations upon encountering new words. At these times there was usually silent or audible spelling of the entire word or some part of it, or attempts at reading by syllables. Examples follow:

Subject No. 4 upon encountering the word *lapse* on the seventh day of practice first hesitated while the word was examined, then spelled *l-a-p*, then, unable to decide whether the following letter was an *a* or an *s*, passed on to the final letter which was also pronounced aloud, *e*. This made it possible to bridge the gap, and the word was correctly pronounced.

That this procedure was frequently employed by all four subjects is evident both from their introspective reports and from such overt behavior as the oral spelling of words or syllables. It was found to occur at two levels, *viz.*: in the apprehension of single words, as in the example given, and in the reading of sentences or phrases, when an entire word might be passed over temporarily to be later supplied by the context. In both instances, however, it seemed probable that the

* M. A. Tinker: Visual Apprehension and Perception in Reading. *Psychology Bulletin*, Vol. XXVI, 1929, pp. 223–240.

context was not the sole factor in supplying the missing element, but rather that it functioned in connection with certain vaguely perceived elements in the total form of word or letter which were not at first sufficiently clear to permit unaided recognition. This viewpoint is in general agreement with the findings of Zeitler,[9] Winch,[8] and Korte.[5]

It is clear that the method just described may give rise to errors as well as to successes. This is illustrated by the treatment given to the word *roused* by the same subject on the same day. The first three letters *r-o-u* were spelled aloud as before, and again the *s* proved a stumbling block. In this case, however, perception of the final letters resulted in an incorrect interpolation of the missing part and the word was finally pronounced *rounded.* The extent to which this method has been employed may be inferred from the distribution of 1795 errors in which the general form of the substituted word was similar to that of the correct word, *i.e.*, differed from it by not more than two letters. For the four subjects combined, the number of such errors occurring at the beginning of the word was only one hundred sixty-four, as compared to seven hundred ninety-six at the end of the word and eight hundred thirty-five in some intervening position. The overwhelming importance of the initial portion of the word for total apprehension has been noted previously by Goldscheider and Müller,[3] Huey,[4] Pillsbury,[7] and others. The corroborative evidence offered by our study has special significance, since it shows that it is the fact of *initial position* rather than location at the right or left side of the word which is the determining factor. This factor is of sufficient strength to cause individuals whose previous reading habits have presumably taught them to give special weight to the letters at the left-hand side of the word, to reverse their habits completely with the reversal of the usual order of letters within the word. While the number of cases is too small to warrant generalization, it is interesting to note that the substituted word is somewhat less likely to involve a change in the context in the case of the two most rapid readers than with the two slower readers. In thirty-one per cent of the errors of this kind made by Subject No. 1 and in twenty-five per cent of those made by Subject No. 2 the substituted word was an approximate synonym for the correct word, as compared to nineteen per cent and eighteen per cent for Subjects No. 3 and No. 4 respectively. This suggests the possibility that the more rapid readers tend to fill in their perceptual gaps upon the basis of larger context-units

than do the slower readers. A somewhat similar situation in the apprehension of single words is suggested by the fact that the two most rapid readers make a greater percentage of the total number of errors in the middle of the word than do the two slower readers. This may be the result of a somewhat greater tendency on the part of the more rapid reader to "jump over" larger areas in the apprehension of words; or, in other words, to identify words upon the basis of a smaller number of "determining" elements. Further data with a larger number of subjects are needed to verify this hypothesis.

Errors of inflection involving a change only in the prefix or suffix with the root word remaining unchanged, have been treated separately. For the four subjects combined, there are eighteen instances of a change in the prefix as compared to three hundred thirty-three instances of a change in the suffix. The importance of the initial position is again clearly demonstrated.

A total of one hundred forty cases in which one word was substituted for another of very different form but of similar meaning were made by the four subjects. Of these ninety-four, or sixty-seven per cent of the total were made by Subject No. 1 who was the most rapid reader. Again the use of larger context-units in the case of this subject is suggested.

Omission of letters or syllables follows the same general pattern as substitution of letters or syllables. Out of a total of one hundred ninety errors of this kind, sixteen occurred at the beginning of a word, forty-four in the middle and one hundred thirty at the end. Fifty-five per cent of the total number were made by Subject No. 1. There were one hundred forty-eight instances of omitted words, and fifty-six instances of inserted words. One hundred forty of the former and forty-two of the latter were attributable to Subject No. 1.

Errors resulting from a reversal of the order of letters within the word, or within some part of the word were of fairly frequent occurrence. There were three hundred forty cases of complete reversal. This category includes all cases in which the beginning and end of the word were interchanged, with or without accompanying reversal of intervening letters. Example: *was* for *saw*, *told* for *dolt*, *on* for *no;* etc. There were one hundred seventy cases in which the reversal affected only a part of the word. These have been classified according to the position of the reversed portion within the word. In thirty-eight cases the order of the letters making up the first syllables was

reversed on initial attempt or pronunciation; *e.g.*, *now* for the first syllable of *wondering*. Errors of this kind were likely to be corrected spontaneously, since as a rule their nature was such that the word could not be sensibly completed without correction. In one hundred sixteen cases the initial and final letters were correct, but a reversal was made within the word. *Form* for *from* and *vice versa* is a common example. There were sixteen cases in which the reversal occurred at the end of the word, as *until* for *unlit*. In thirty-four cases the order of words within a phrase or short sentence was reversed, as *is it* for *it is*, etc.

It is impossible to say to what extent these reversals are the direct result of interference from the normal reading-habit and to what extent they represent perceptual difficulties of a more fundamental nature. Every primary teacher knows the difficulty which most beginning readers experience in learning to distinguish between such words as *was* and *saw; felt* and *let;* on and *no*, etc. That interference factors were operative to some extent, at least, in the present experiment was evident both from the introspective reports of the subjects, and from their overt behavior. In the beginning of the experiment all subjects reported that the page not only appeared to be reversed from right to left but also to be upside down. This led to considerable difficulty in passing from one line to another or in going from page to page. One subject almost invariably began a new page at the bottom instead of the top, and for all there was a perceptible period of fumbling adjustment at the beginning of each new page during the early part of the experiment. All found it more or less difficult to shift from line to line; and not infrequently the device so often employed by little children under similar difficulties—that of following the line with the finger or of pointing to each successive line in order to keep the place was brought into use. In spite of these devices, and the early recognition of the existence of this particular type of difficulty by all four subjects, in twenty-one cases an entire line was omitted in reading; in seven cases a line was repeated, and in two additional cases the fixation point shifted to the adjacent line without awareness on the part of the subject, who, as a result, read half of one line and half of the following line.

The effect of interference is also seen in certain letter-confusions which were frequently made. It is a matter of common observation that normal children upon learning to read rarely have much trouble in learning to distinguish words or letters upon a vertical or up-and-

down basis, but that the horizontal, or right-and-left distinction frequently causes much trouble. As Terman has expressed it ("Measurement of Intelligence," p. 177) "it is the "*p*'s" and "*q*'s" that children must be told to mind; not the "*p*'s" and "*b*'s." For all subjects, however, *d* and *p* were confused more frequently than any other letters, with *b* and *d* as a close second. The operation of the "up-side-down" illusion has almost certainly been the determining factor in the first instance. Other letters frequently confused were *a* and *s*, *h* and *b*, and *w* and *m*. In general it may be said that such confusion is most apparent in the case of letters made up of identical or closely similar elements, thus necessitating a distinction upon the basis of spatial position only.

Although it is evident that a comparison of word-confusions or letter-confusions within material such as this, where individual words or letters occurred with unequal frequency, and therefore had unequal chances to be confused, does not permit too wide generalization, it has nevertheless seemed worth while to tabulate the word-confusions which were found to occur most frequently within the limits of our material. The results of this tabulation are shown below.

Of for *to* (or *vice versa*), 88; *on—no*, 68; *saw—was*, 60; *the—this*, 19; *that—this*, 14; *left—felt*, 12; *now—won*, 11; *tell—let*, 11; *the—that*, 9; *the—his*, 8; *face—fact*, 7; *physiological—psychological*, 7; *and—any*, 7; *though—through*, 6; *part—past*, 6; *him—his*, 5; *to—or*, 5; *ever—even*, 5; *whatever—whether*, 5; *and—but*, 3; *started—stared*, 3; *for—of*, 3; *put—but*, 3.

The findings of Erdmann and Dodge[2] and of Pillsbury[7] appear to show that word-length is an important factor in the determination of word-form. Zeitler[9] on the other hand, regards word-length as a factor of minor importance. Our findings clearly bear out the former viewpoint. A tabulation of a total of 2812 errors (not including omission or insertion of entire words) yielded the following results:

No change in number of letters, 1505 cases; difference of one letter, 1027 cases; of two letters, 202 cases; of three letters, 55 cases; of four letters, 17 cases; of five letters, 3 cases; of six letters, 2 cases; of seven letters, 1 case.

It will be noted that ninety per cent of the errors do not involve a change in word length of more than one letter. An examination of the nature of the most frequent errors as reported in a foregoing paragraph will show that in none of these instances is the change in word length

greater than one letter, while in eighty-five per cent of the errors included within this list, no change in word length has taken place.

Since only four subjects participated in the experiment, it was thought that it would be worth while to see to what extent individual idiosyncrasies might be affecting the general trend of the results; or, in other words, to see to what extent the distribution of the various kinds of error might vary from subject to subject. We have therefore classified the errors made by each subject under the different heads discussed previously, and then computed the rank-order correlation between the comparative frequency of the various types of error for each subject with every other subject. The categories used in classifying the errors will be repeated here for convenience.

Omission of line
Repetition of line
Mixing up two lines
Omission of letters or syllables at beginning of word
Omission of letters or syllables at end of word
Omission of letters or syllables in middle of word
Substitution or addition of letters at beginning of word
Substitution or addition of letters at end of word
Substitution or addition of letters in middle of word
Reversal of entire word
Partial reversal at beginning of word
Partial reversal at end of word
Partial reversal in middle of word
Reversal of words or phrases
Phrases substituted or added.

The inter-correlation between the order of frequency of the various types of error for the four subjects ranged from +.57 to +.85 with an average intercorrelation of +.75. In a similar manner we have computed the rank-order correlations between the frequency of various single-letter confusions for the four subjects, using only the twelve confusions most frequently made, and in this case differentiating between the two alternatives in each pair. The list of confusions follows: *b* for *d*, *b* for *p*, *d* for *b*, *d* for *p*, *f* for *t*, *p* for *b*, *p* for *d*, *a* for *s*, *h* for *b*, *w* for *m*, *t* for *f*, *s* for *a*. In this case the inter-correlations ranged from +.26–+.78 with an average inter-correlation of +.59. This is in close agreement with the correspondence between individuals found in most of the reported studies on the relative legibility of individual letters.

Summary

1. The results of a learning experiment in the reading of English prose from the reversed image shown in a mirror have been utilized for the study of certain factors influencing word-perception.

2. Four adult readers participated in the experiment. Practice for ten minutes daily was carried out by each subject over a period of approximately five months. Marked individual differences in speed of reading were apparent from the beginning, and these differences tended to increase with practice.

3. An analysis of the errors made in terms of their position within the word yielded results which are in conformity with those of certain previous investigators in the following respects: (1) The initial letters were found to be of far greater importance in the apprehension of words than the final or the intermediate letters, (2) The context was frequently utilized in the final apprehension of difficult words or in deciding among the various alternatives suggested by imperfect or partial perception, (3)Word-length appeared to be a factor of major importance in determining word-form.

4. Interference from the normal reading habit was shown, not only in the reversal of letters or of letter-elements in the horizontal direction which is a difficulty frequently found among children when first learning to read, but also in the presence of a definite "up-side-down" illusion which tended to produce similar confusion in the vertical direction.

5. A fair degree of correspondence was found among the four subjects in regard to the relative frequency of the different kinds of error made. The mean inter-correlation of the order of frequency of certain specified errors classified on the basis of their nature and their position within the word was +.75 for the four subjects; between the frequency rank-orders of the twelve most common letter confusions was +.59.

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THE RETENTION OF MIRROR-READING ABILITY AFTER TWO YEARS

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This study was designed to supplement an earlier investigation by the authors[1] on progress in learning to read ordinary prose material as viewed in a mirror.

Four subjects participated in the original study. Practice was carried out for ten minutes daily over a period of approximately seventeen weeks.

Two years later, an experiment in relearning was undertaken. Ten minute practice periods were employed as before. Practice was continued for twenty consecutive days. The book used was "Psychology; Its Facts and Principles," by H. L. Hollingworth. The first half of this book had been read at the end of the original learning study. For re-learning the second half was used, thus insuring similarity of subject-matter without the use of identical material. All four of the subjects participated in relearning. None had had any intervening practice.

A comparison of the number of lines read per day during the re-learning period with the corresponding number read during the original learning is presented in Table I.

In this table the mean number of lines read during each successive five-day period of the relearning experiment is compared with the final stages of the original learning in which the first part of the same book was used. The number of days practice on this book was the same for both learning and relearning.

The rank-order of the four subjects is the same for both learning and relearning, if the average for the twenty days of practice is considered. With few exceptions, this is also true when the data are grouped by successive five-day stages. Two of the four subjects make a distinctly higher score on the relearning than was made during the final period of learning, in spite of the fact that there had been no intervening practice. The remaining two subjects made approximately the same average scores on both learning and relearning.

[1] Tinker, M. A. and Goodenough, F. L.: Mirror Reading as a Method of Analyzing Factors Involved in Word-perception. THIS JOURNAL 1931, Vol. XXII, pp. 493.

TABLE I.—COMPARISON OF LEARNING AND RELEARNING SCORES IN MIRROR READING

Subject	Days, 1–5		Days, 6–10		Days, 11–15		Days, 16–20		Average of all trials	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*
1.....	131.8	130.4	139.4	142.2	145.6	136.0	150.4	138.2	141.8	142.2
2.....	80.2	81.2	82.6	102.8	80.8	99.6	82.4	93.0	81.5	94.1
3.....	75.2	80.0	78.6	99.0	82.2	88.6	81.1	87.6	79.4	88.8
4.....	65.2	74.0	74.8	81.4	81.8	77.8	94.4	80.8	79.1	78.5

L, mean number of lines read per day during the original learning period.

R, mean number read during relearning (different portions of the same book used).

One gained 0.4 of a line; the other lost 0.6 of a line. When the average score for the first five days of relearning is compared with the last five days of the original learning, all subjects show a slight loss, but this loss was more than recovered by the end of the second five-day period of relearning. These results indicate that with adult subjects, retention in mirror-reading tends to persist with practically no loss in efficiency for a period of at least two years.

VOCATIONAL INTERESTS AND TYPES OF ABILITY

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This paper presents estimates of the inter-correlations between fifteen of the vocations measured by Strong's Vocational Interest Blank, and offers a partial analysis of the types of interest which are in part responsible for the degree of correlation.

We have several times found a need for a knowledge of the inter-relations between the various occupational groups measured by the Vocational Interest Blank. The manual of directions contains figures of inter-correlations for about twenty pairs of vocations; but there are stencils and norms for almost that many occupations. The manual, further, gives no indication as to the number of cases upon which the correlations are based, or the PE's of the correlations. It would be an enormous task to work out the actual inter-correlations with an adequate number of cases.

Our own efforts were directed toward obtaining, fairly easily, an estimate of the actual correlations. Instead of using scores made by various individuals upon the tests, we used the stencils themselves; instead of using the fully weighted scores, we used only the sign of the score; and instead of using the total blank, we used only four of the sub-tests (1A, 1B, 7 and 8). A relative measure of the degree of correlation in interests between two vocations in each of these sub-tests was obtained by determining the number of agreements in sign in the "Like," "Indifferent" and "Dislike" columns for all items; and from this figure was subtracted the number of agreements which would be expected purely by chance. When these data from all the vocations and sub-tests used were added and assembled in a table, the rough relations between the various occupations could be seen, but their significance in terms of the coefficient of correlation could not, of course, be determined. To make a conversion possible, these figures were correlated with actually determined correlations between vocations. The actual correlations were obtained from those published in the manual of directions and from Correlations we had determined. Strong does not state the number of cases upon which his correlations are based. Ours are based only upon fifteen to forty cases. When a value for any pair of interests occurred in both sources, the average was taken. There were finally thirty-four different correlations,

TABLE I.—ESTIMATED INTER-CORRELATIONS BETWEEN VOCATIONAL INTERESTS

$PE_{est.}$ is .075

	Lawyer	Journalist	Engineering	Certified Public Accountant	Advertiser	Architect	Doctor	Psychologist	Chemist	Personnel Manager	Purchasing Agent	Real Estate	Teacher	Minister	Life Insurance
Lawyer		.99	.27	.59	.73	.39	.63	.39	.41	.13	.03	.59	.06	.09	.34
Journalist	.99		.47	.53	.97	.48	.56	.36	.003	.10	.19	.60	.05	.03	.22
Engineering	.27	.47		.48	.38	.56	.56	.39	.78	.35	.60	.13	.31	−.15	.17
Certified Public Accountant	.59	.53	.48		.33	.51	.32	.25	.18	.31	.23	.35	.35	.05	.17
Advertiser	.73	.97	.38	.33		.35	.23	.28	.05	.15	.33	.71	−.10	−.10	.30
Architect	.39	.48	.56	.51	.35		.57	.45	.61	.23	.50	.07	.05	−.10	−.07
Doctor	.63	.56	.56	.32	.23	.57		.45	.58	−.16	.20	.19	−.02	.11	.08
Psychologist	.39	.36	.39	.25	.28	.45	.45		.65	.25	−.05	−.35	.48	.54	−.35
Chemist	.41	.003	.78	.18	.05	.61	.58	.65		.33	.31	−.24	.19	.02	−.53
Personnel Manager	.13	.10	.35	.31	.15	.23	−.16	.25	.33		.33	.03	.54	.38	.15
Purchasing Agent	.03	.19	.60	.23	.33	.50	.20	−.05	.31	.33		.36	−.11	−.17	.11
Real Estate	.59	.60	.13	.35	.71	.07	.19	−.35	−.24	.03	.36		−.29	−.30	.83
Teacher	.06	.05	.31	.35	−.10	.05	−.02	.48	.19	.54	−.11	−.29		.84	.04
Minister	.09	.03	−.15	.05	−.10	−.10	.11	.54	.02	.38	−.17	−.30	.84		.01
Life Insurance	.34	.22	−.17	.17	.30	−.07	.08	−.35	−.53	.15	.11	.83	.04	.01	
Average	.564	.555	.496	.465	.461	.460	.430	.374	.334	.312	.286	.268	.239	.125	.113

ranging from $-.10$ to .88, which were plotted against the corresponding estimates. The correlation between the actual correlations of interests, and the estimates of agreement, based upon the signs of the weights, is $.918 \pm .0175$. By means of the obtained regression equation each of the values in the table giving the relative closeness of agreement of the vocational interests was converted into its most probable correlational value. Table I gives these estimated intercorrelations. The $PE_{est.}$ is .075. As a check, the differences between the thirty-four actually determined and the corresponding predicted correlations were plotted: The PE of the distribution was .079.

Even a casual inspection of the table shows many indications of group factors. Since the actual basis of the degree of correlation between any pair of vocations can be found in the stencils, an analysis of factors involved could readily be made providing there was a significant set of categories for classifying the various items. Following Thorndike's suggestion that there are perhaps three types of intelligence, and assuming a close relation between interest and ability, we first attempted a classification in terms of the categories, Abstract, Mechanical and Social. It soon appeared that these classes needed amplification and subdivision. After several trials, what appeared to be a fairly complete classification, with five main headings and a total of twelve sub-headings was constructed. Three of the main headings correspond to Thorndike's Abstract, Social and Mechanical intelligence. The remaining headings collect the rather miscellaneous sub-groups that fitted in no particular place. Nine different individuals, representing five departments of instruction, acted as judges. The judges classified the items in entire independence of each other; and in view of their complaints as to the difficulty of making the classifications, the amount of agreement among them is surprising. The judges omitted a number of items which they held were not classifiable into these types of categories. Hence only the first four sub-tests of the Blank were eventually used. The judges were asked to indicate which items they felt belonged under the following headings:

(*A*) Social interests
1. Desire to dominate or boss a group (army officer).
2. Desire to be exhibited before a group (actor).
3. Desire to mingle in a crowd (picnics).

(*B*) Intellectual interests
4. Empirical (physics).
5. Abstract (mathematics).

(*C*) Technical interests
  6. Clerical (bookkeeper).
  7. Mechanical (auto repair man).
  8. Technical-professional (dentist).

(*D*) Creative interests
  9. Artistic (artist).
  10. Practical (music teacher).

(*E*) Interest in physical skill
  11. Competitive (auto racer).
  12. Non-competitive (taking walks).

Those items which four or more of the nine judges agreed in classing under the same heading were considered as properly placed. All others were omitted.

It remained to compare each of the stencils for the various vocations with this analysis of the interests. Any item in the Interest Blank may be marked "Like," "Indifferent" or "Dislike." For any particular interest any of these alternatives may be weighted much or little, and with a plus or a minus score. All "Indifferent" scores were ignored. Only fairly heavily weighted positive or negative scores (four or five, depending upon how many such items appeared in the particular vocation) were considered. Score was totaled by counting one each for positively weighted "Like" items and negatively weighted "Dislike" items; and by subtracting one each for negatively weighted "Like" items and positively weighted "Dislike" items. Accordingly it was possible in scoring one vocation to have a count of zero, one or two (plus or minus) for every item. Table II presents scores obtained in this fashion for fifteen vocations for the various types of interest, converted into per cent of perfect score. The Minister's score, *e.g.*, of fifty per cent under Creative artistic interests, means that that profession had a score of seventeen on these seventeen items.

Considering the various vocations as wholes, it first appears that none of the vocations can be said to depend only upon one or another of the major groups of interests. A very important factor seems to be what members of the vocations dislike. Real Estate Salesmen, and to a lesser extent, Lawyers and Journalists, are characterized chiefly by their almost universal dislikes; while the Ministers, and to a lesser extent the Teachers and Personnel Managers, are characterized by omnoverous likings. The interesting characteristics of the individual vocations are too numerous and too readily observed to be noted.

We may now turn to the relations between the groups of interest. If Thorndike's suggestion that there are three types of intelligence

TABLE II.—ANALYSIS OF THE TYPES OF INTEREST FOR EACH VOCATION (IN PER CENT)

Class	Social			Intellectual		Technical			Creative		Skill	
Number of items	B twenty-four	E thir-teen	M six-teen	E twenty-six	A fif-teen	C twelve	M twenty-six	T six-teen	A seven-teen	P eight	Ph eight	N four
Lawyer	−42	0	−19	10	0	−25	−38	−53	−15	−38	−25	0
Journalist	−25	0	−3	−4	−30	−46	−38	−56	6	13	−25	−50
Engineering	−10	−42	−9	21	30	−21	35	−9	−9	−6	−13	0
Certified Public Accountant	−17	−12	−3	0	27	29	−4	13	0	13	−13	−13
Advertiser	−19	−4	−31	2	−13	−71	−33	−44	15	0	6	0
Architect	−35	−23	−16	−6	−3	−58	4	−9	41	44	−6	−25
Doctor	−42	−27	−16	17	7	−63	0	−9	−3	0	−13	0
Psychologist	−25	−8	−6	+36	33	−21	10	0	12	38	−25	0
Chemist	−6	−15	−13	17	27	−33	29	22	0	19	−13	25
Personnel Manager	29	0	19	27	0	0	19	9	0	0	0	13
Purchasing Agent	4	0	−7	−25	−30	13	4	13	−35	−19	19	0
Real Estate Salesman	4	0	−13	−36	−53	−50	−58	−28	−44	−38	0	0
Teacher	2	−4	9	33	40	21	−2	−9	21	25	0	13
Minister	13	12	−13	35	50	13	4	13	50	25	−6	0
Life Insurance Salesman	17	0	13	−19	−20	0	35	0	0	0	13	0

Social, B—boss, E—exhibitor, M—unobtrusive mingler.
Intellectual, E—empirical, A—abstract.
Technical, C—clerical, M—mechanical, T—technical professional.
Creative, A—artistic, P—practical.
Skill, Ph—physical competitive, N—non-competitive.

is true; and if, as has been fairly well established, there is a close relation between abilities and interests, then the correlations between the classes within each of our major headings should be high, and the correlation between any member of one group and any member of another group should be low. To facilitate such a comparison, rank-

TABLE III.—INTERCORRELATIONS BETWEEN THE VARIOUS CLASSES OF INTERESTS (RANK-DIFFERENCE METHOD)

	Social			Intellectual		Technical			Creative		Skill
	B	E	M	E	A	C	M	T	A	P	Ph
Social											
B.....		.53	.50	.02	.22	.61	.40	.54	−.10	−.19	.69
E.....	.53		.28	−.12	−.29	.33	−.22	.03	.04	−.19	.35
M.....	.50	.28		.10	−.07	.69	.36	.36	.05	.16	.20
Intellectual											
E.....	.02	−.12	.10		.89	.26	.34	.03	.47	.46	−.35
A.....	.22	−.29	−.07	.89		.43	.36	.41	.46	.55	−.33
Technical											
C.....	.61	.33	.69	.26	.43		.28	.58	.09	.13	.19
M.....	.40	−.22	.36	.34	.36	.28		.63	.11	.25	.17
T.....	.54	.03	.36	.03	.41	.58	.63		.09	.32	.25
Creative											
A.....	−.10	.04	.05	.47	.46	.09	.11	.09		.88	.01
P.....	−.19	−.19	.16	.46	.55	.13	.25	.32	.88		−.18
Skill											
Ph.....	.69	.35	.20	−.35	−.33	.19	.17	.25	.01	−.18	

Social, B—boss, E—exhibitor, M—unobtrusive mingler.
Intellectual, E—empirical, A—abstract.
Technical, C—clerical, M—mechanical, T—technical professional.
Creative, A—artistic, P—practical.
Skill, Ph—physical, competitive; N—non-competitive has too few cases.

order correlations between the classes of interests were worked out (Table III). Fairly high correlations obtain between the two Intellectual and between the two Creative classes of interests. The various Social classes and Technical classes, however, do not have such high intercorrelations. In fact, the averages both of the correlations of Clerical interests with the three Social classes, and of Practical Crea-

tive interests with the two Intellectual classes are higher than the average inter-correlations either of the Social or the Technical classes of interest.

If our final analysis is correct, the grouping of "Social" interests, and of "Technical" interests into single categories covers up many actual differences. We cannot agree that the terms "Social," "Abstract" and "Mechanical" stand for three homogeneous, mutually independent, and collectively exhaustive categories of ability.

A VOCABULARY STUDY OF BIOLOGY NOTEBOOKS OF FIFTY REPRESENTATIVE SECONDARY SCHOOLS IN NEW YORK STATE

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There have been many vocabulary studies made in recent years, especially in the field of elementary education. Thorndike's "Teacher's Word Book" was a result of an extensive and comprehensive study of the vocabularies of elementary pupils and average citizens. Recently Selke made a study of words in ten well-known textbooks in spelling in which he shows very clearly that the problem of vocabularies is by no means solved. Powers made a "List of Scientific Terms for High School Students," in which he lists the most important words from the field of natural science for pupils of the high school level. Many others, as Bonser, Doran, Neher, Brandenburg, and Symonds, have contributed to research work in the various phases of vocabulary investigations.

The study here presented was made to determine whether there is close agreement in the vocabularies used in biology textbooks and biology notebooks as written by high school pupils, and to compare the scientific terms used in such notebooks with those found in Powers "List of Scientific Terms for High School Students" and with those found in Thorndike's "Teacher's Word Book."

The writer collected biology notebooks from pupils in fifty representative secondary schools in New York State. These notebooks were selected from the several classes in secondary school biology as good but not the best of each biology class. The pupil vocabulary in these notebooks was examined to determine the following: extent of pupil vocabulary; extent of the use of scientific terms; the total number of words used; and the correct use and spelling of words.

The total of all the separate words used in the notebooks was checked against the Thorndike list and the Powers list. In making up the list of words used in the notebooks proper names and symbols were counted in the total count for all the notebooks. The first step in discovering the extent of the pupil vocabulary as represented in the notebooks was a study of one of the smaller and one of the larger notebooks for comparison and to provide an initial word list for further

study. Table I shows the results from the comparative study of the two notebooks.

TABLE I.—SUMMARY OF VOCABULARY STUDY OF ONE OF THE SMALLER AND ONE OF THE LARGER NOTEBOOKS

	Smaller notebook	Larger notebook
Number of words used but once	167	653
Number of words used one to four times	313	1,223
Number of words used five or more times	109	558
Total separate words used	422	1,781
Number of proper names	15	121
Number of symbols used	10	74
Number of abbreviations used	4	4
Total number of words used	2,220	15,249
Total number of words, including symbols, proper names, and abbreviations	2,259	15,448
Number of words not found in Thorndike's list	61	287
Number of scientific terms not found in Powers' list	7	68

The total number of scientific terms used in all the notebooks is six hundred forty-five. Many of the scientific terms were used but once in a single notebook. Comparatively few words were found to be misspelled and but few words "coined" by the pupils. Table II gives a summary of the vocabulary study of fifty-two of the notebooks.

TABLE II.—SUMMARY OF THE VOCABULARY STUDY

Total number of words used	488,826
Total number of separate words used	2,358
Total number of words not found in Thorndike's list	344
Total number of words not found in Powers' list	87

TABLE III.—WORDS IN THE NOTEBOOKS NOT FOUND IN THORNDIKE'S TEACHER'S WORD BOOK, OR IN POWERS' LIST OF SCIENTIFIC TERMS FOR HIGH SCHOOL STUDENTS

Absorption	Amoeba	*Apex	*Astigmatism
Adaptation	Amphibia	Aphid	Auditory
Adenoids	*Anal	Appendage	Auricle
*Advocacy	Anopheles	*Arterial	
Aeration	Antennae	Artery	Bacillus
Agar agar	Anther	*Ashy	Bacteria
*Ahead	Antibody	Assimilate	Bacteriology
Alimentary	Aorta	*Assimilation	*Bag-like

TABLE III.—*Continued*

*Bailers
Bast
*Batting
Beaker
Beneficial
Bichloride
*Biconcave
*Bicuspid
Bile
Biology
*Blotter
Boll
*Box elder
*Bronchial
Burdock

Calyx
Cambrium
Capillary
Capsule
Carapace
Carbohydrate
Carpel
*Carrion
Caudal
Cavity
Cellulose
Cephalothorax
Cerebellum
Cerebrum
Char
*Chitin
*Chlorate
Chlorophyll
Chloroplast
*Chyle
*Chyme
Cilia
Ciliate
*Cinnamon
Cloaca
Clot
*Coccus
Cochlea
*Cochineal
Cocklebur
Codlin
Combustion
Complex
Concave
Conservation
Convex
*Convolution
Coordinate
*Coordination
Cornea
Corolla
Corpuscle
Cortex
Cotyledon
*Coxa
Crayfish
*Cross bill
*Cross section
Cross-pollinate
Crucible
Crustacea
Cytoplasm

*Daddy-longlegs
*Decrease
Dehiscent
*Derangement
Devastate
*Dexterity
Diastase
Dicotyledon
Dioxide
Disinfectant
*Dissect
*Dissension
Dormant
Dorsal
Drupe

*Ectoplasm
Edible
Embryo
*Emulsion
Encyst
*Endoplasm
Endosperm
Enzyme
*Epicotyl
Epidermis
Erosion
Esophagus
Ether
Eustachian
*Everytime
Excretion
Exoskeleton
Explode

Facet
Fahrenheit
*Fan-like
Fehling
Fermentation
Filament
Filter
*Flower-like
Focus
Follicle
*Fork-like
Formaldehyde
Fumigate

Gastric
Generalization
Generate
Germinate
*Glottis
Gram
Grippe
Gullet

Heliotropism
*Hessian
*Hibernation
Hydrochloric
Hydrogen
Hydrophobia
Hydroxide
Hygiene
Hygienic
Hypocotyl
Hypo-pharynx

Ichenumon
Ignite
Indigestible
Inorganic
Insecta
Insoluble
Integument

Katydid

Labrum
Lacteal
Larva
Larynx
Lateral
Legume
Lengthwise
Lenticel
Liberate
*Licorice
Limestone
*Lysol

Maggot
Malaria
Mammal
Mandible
*Mandrake
Masticate
Maxilla
Medulla
Medullary
Membrane
Membranous
Merge
Mesothorax
Metamorphosis
*Metathorax
Metazoan
Micropyle
*Microsca
Microscope
Microscopic
*Mold
Mollusk
Monocotyledon
Monocotyledonous

Narcotic

TABLE III.—*Continued*

Necessitate	Photosynthesis	Saliva	*Sunlight
*Neuron	Physiologic	Salivary	Swimmeret
Nicotine	Pigment	*Salts	
Nitric (acid)	Pinnate	*Sawdust	Tachina fly
Nitrogen	*Pisces	Scavenger	Tactile
Nitrogenous	Pistil	Scientist	*Taproot
Nodule	Placenta	*Sclerotic	*Telson
*Non-fatty	Plasma	Sebaceous	Testa
Nucleus	*Pliable	Secrete	Thoracic
Nutrient	Plumule	Secretion	Thorax
	Pollination	Segement	Tibia
*One-celled	Pome	Segmental	Trachea
Operculum	Posterior	Self-control	Translucent
Opium	Potassium	*Semicircular	*Transparent
Osmosis	Protein	*Semifluid	Transpiration
Ovary	*Prothorax	Sensory	*Trichocyst
*Over done	Protoplasm	*Sheeting	*Tricuspid
Ovipositor	Protozoa	Soluble	*Trillum
Ovule	Pseudopodia	Spiracle	*Trochanter
Oxidation	Ptyalin	Spirillum	Trypsin
Oxidize	Pulmonary	Spore	*Tsetse
Oxygen		*Sputter	*Tweezers
	Quarantine	Sputum	*Typhoid
Palisade		Stamen	
Palmate	Rabies	*Starling	*Unglaze
Palpus	*Rakers (Gill)	*Steapsin	Urea
Pancreas	*Raphe	*Stegomyia	Ureter
Pancreatic	Reflex	Sterilization	
Papilla	Reproduce	Stigma	Vaccination
Paramecium	Reproduction	Stimulant	Vacuole
Parsnip	*Respiration	Stimulate	Ventral
Pectoral	Respiratory	Stimulus	Vertebrate
Pelvic	Retina	*Stipule	Vireo
Pelvis	Rhubarb	Stoma	
*Pericardium	Rodent	Stomata	Weevil
Petiole	*Rod-shape	*Stopper	
Pharynx	Rootlet	Suffocate	Xylem

* Not in Powers' list.

Concluding, the writer would say it is evident that biology has a technical vocabulary more or less peculiar to it, and that the acquirement of this vocabulary by pupils is no easy task. There is a considerable range of scientific terms used in the several textbooks of secondary school biology and, as found in the notebooks, some of these terms are used but once by pupils. This would seem to indicate that the technical vocabulary of the textbooks may well be simplified,

especially since many of the scientific terms are not found in Powers' "List of Scientific Terms for High School Students." The fact that relatively few words were misspelled or incorrectly used is noteworthy. It is also evident that a general vocabulary of less than two thousand words is sufficient for the average high school pupil in the study of elementary biology.

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MECHANICAL "APTITUDE" OR MECHANICAL "ABILITY"?—A STUDY IN METHOD

O. L. HARVEY

In 1928 John Cox, a pupil of Spearman, stated the major findings on his doctorate dissertation* on mechanical aptitude as follows:

> The application of the tetrad-difference criterion to our specific correlation coefficients has failed to disclose the presence, here, of group factors . . . The resulting specific correlation is adequately explained by a single factor running through those measurements in which this correlation occurs (130).

In a brief discussion of its relation to other "abilities," he pointed out that "mechanical aptitude" is to be strictly differentiated from "motor ability," which form of activity was "specially avoided" in his tests.

> Seeing, however, that the perception of space is largely developed by the aid of motor sensations, and that the material of the tests was spacial, it might appear at first sight that motor activity was an indirect determinant of success in dealing with this material. But the precise estimation of shapes, sizes, and distances, in which motor experiences might conceivably play a part, was not required in the tests. The essential processes on which success or failure turned were not perceptual but of the eductive kind in which motor experience could hardly have assisted (167–168).

In the initial definition of his problem, concerning the use of the term "aptitude," Cox wrote:

> Since the term "ability" must obviously extend its meaning to cover any kind of performance whatever, it would seem desirable to continue its employment in this wide sense, and to use the term "aptitude" when only the innate character of the "ability" is intended. Employing the terms in this way, we should say that a person actually able to carry out "mechanical" work has "mechanical ability," while one who has the appropriate innate mental constitution for acquiring this ability (whether he has actually done so or not) may be said to possess "mechanical aptitude" (40–41).

In these three key-statements, then, Cox makes his position clear, namely:

1. That he sought to discover, if possible, that innate "aptitude" which underlies the ability to carry out mechanical work;
2. That, as the result of experimentation, such an aptitude was found actually to exist;
3. That it is unique in its relation to "*g*" (Spearman's "general factor");
4. That it is a single group factor; and
5. That it is not the same as motor ability.

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* Cox, J. W.: "Mechanical Aptitude." London, Metheun, 1928, pp. 210.

The instruments (tests) used by Cox consisted of mechanical models and diagrams of various sorts, which his subjects were required to explain or complete in one way or another, verbally. That is, the function of the subjects was essentially eductive, non-manipulative, non-motor. Although it may be argued that, for eductive processes to be possible, certain implicit motor responses must have been involved, at least in the past acquisition of habits, nevertheless the actual test-situation involved no overt neuro-muscular behavior.

Two years after Cox's work had been published there appeared a comprehensive study of mechanical ability* made possible by grants from the National Research Council. Presumably Cox's work was unknown to the authors of this volume, at any rate until after their own study had been completed, for no reference is made to it. Their findings are, nevertheless, at least in their major reference, the same as his. "As regards the uniqueness of mechanical ability," they wrote, "the evidence is consistently positive" (253). On the other hand (in contradiction to Cox's findings),

> mechanical ability . . . probably does not involve any single general factor. Low intercorrelations between different measures of mechanical ability suggest that factors of high specificity play a major rôle (300).

Mechanical ability they found to be "unique with respect to intelligence and also with respect to motor agility" (301), this last term being used synonymously with "motor ability," and being measured by means of parts of the Garfiel motor (gymnasium) test.

The term "mechanical ability" was defined in this study to mean

> the ability to succeed in the actual manipulation of tools and materials and the ability to secure information about tools, and materials, and their uses (7).

It is to be differentiated from mechanical "capacity," (a term which, to the present writer, appears to be somewhat synonymous in this context with Cox's "mechanical aptitude"†).

The position of the co-authors of this group-study is thus made clear, as follows:

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* Paterson D. G. *et al.:* "Minnesota Mechanical Ability Tests." Minnesota University Press, 1930, pages XXII + 586.

† "Capacity," wrote the authors, "is always an inference from measured ability . . . For it is by no means evident that the development of mechanical ability may not be determined to a considerable extent by the presence and availability of tools and mechanical equipment" (7–8).

1. That they sought to discover whether there were a "mechanical ability," that is, the ability to succeed in the actual manipulation of tools and materials, regardless as to whether or not that "ability" be entirely attributable to innate capacity;
2. That, as the outcome of experimentation, they have revealed such an ability;
3. That it is unique in relation to verbal intelligence;
4. That it is, however, probably not a single group factor, but a constellation of factors of high specificity;
5. That it is unique in relation to motor agility.

The instruments (tests) selected as their final battery for the measurement of this "mechanical ability" comprize: (*a*) a test of steadiness, (*b*) a card-sorting test, (*c*) a block-packing test, (*d*) a form-board (spatial-relations) test, (*e*) an assembly test, (*f*) a test of mechanical knowledge (Stenquist's "mechanical aptitude"), and (*g*) a paper formboard test. Of these, the first three would appear, at least in the judgment of the writer, to be closely similar to tests constituting part of the Miles-Seashore "motor skills" unit;* whereas the spatial relations and assembly tests involve considerable manipulation.†

In so far as these two studies both claim to have isolated and discovered "*m*," they agree; in so far as the one clearly demonstrates "*m*" to be a single group factor, whereas the other equally clearly shows that very probably it is not a single group factor, but rather consists of a number of highly specific factors, they are in frank contradiction.

Professing to be no more than an interested onlooker in respect to the present discussions in this field, the writer has, nevertheless, ventured to seek explanations for this contradiction. He submits the following arguments, therefore, with considerable diffidence, hoping merely to attempt to clear up the differences which he finds.

Definitions, and Delimitation of Field of Inquiry

Possibly a significant reason for the difference in findings lies in the definition of the field of investigation. Although both studies claim to have revealed "*m*," actually Cox limits his investigation to the aptitude which makes mechanical ability possible; it excludes manipulative ability; it deals purely with the cognitive processes

* A study not included in the Minnesota bibliography, but reported in detail in *Journal of General Psychology*, Vol. III, 1930, pp. 38–65.

† In this connection see criticism by Cox (pp. 16–21, 166–168).

involved in the eduction of spatial relations. The Minnesota study, on the contrary, clearly seeks to measure manipulative ability pure, the ability to use tools and materials. If, then, the ability to educe spatial relations is a function actually distinct from the ability to manipulate objects, it would appear evident that confusion has arisen out of the use of the designation "*m*." In which case, perhaps all that is necessary is to decide on some other symbolic designation for the factor of "mechanical ability." The real difference, however, appears to be more fundamental than one of definition alone, as will appear in the later discussion.

Basis of Selection of Tests

In line with the difference in definition of fields of investigation is the difference in basis of selection of tests. Cox decides against all available tests and constructs his own—tests involving, be it noted, no overt manipulative or motor activity on part of his subjects. Thus it could be argued that Cox's claim that "*m*" is not related to motor activity is substantiated by definition. The Minnesota group is equally consistent, but strictly in terms of technique, not of philosophical orientation. Tests, roughly designated "mechanical," are correlated first with verbal intelligence and then with a shop-criterion, which, although of high reliability, is nevertheless, from the point of view of functional integrity, a somewhat ambiguous conglomerate. Those tests which correlate as low as possible with intelligence and as high as possible with the criterion are selected to constitute the final battery—a basis of selection comparable, one suspects, with judgment in terms of the letter rather than of the spirit of the law.

Spurious Average Intercorrelations

Indeed it would appear that the nature of the tests determines the outcome. One actually expects Cox to discover marked consistency among his tests.* On the other hand, although the Minnesota tests are to be clearly differentiated from verbal intelligence, the fact that, taken as a group, they result in a low average intercorrelation does not necessarily mean that here is evidence of the absence of a large single group factor. An examination of Table XXXVI (page 233), "Inter-

* It is not necessarily implied by this argument that Cox's "*m*" factor includes all available tests of "*m*." The denotation of a group factor, as the writer understands it, is a matter of proof, which Cox has not submitted. Nevertheless, so far as he has gone, his tests consistently agree.

correlations of mechanical ability tests used in experiment proper, corrected for attenuation," yields an interesting observation suggestively in confirmation of this comment. Tests 1, 2, and 5 are as nearly as one could wish tests similar to those described by Seashore (*loc. cit.*) as purely motor tests; whereas Tests 4 and 7 are essentially "manipulative" and probably in part "eductive"—that is, in the sense in which these terms are used by Cox in the critical review at the commencement of his thesis. The average intercorrelation of all seven tests is .27. But, when taken alone, the average intercorrelation between the three motor tests is as low as .23* while the correlation between the two tests involving manipulation is actually as high as .63. And a similar argument applies in respect of all of the tables submitted on pages 432–433, 235, 238, and 232.† Intercorrelate the tests which are, as nearly as one can judge, purely motor; intercorrelate, again, those which are both manipulative and eductive; exclude altogether those which fall into neither category; and consistently one discovers a high average intercorrelation for the manipulative tests, while the motor tests intercorrelate even lower than the average for the entire table as given by the authors, and in each case the range of correlations is narrower. Does not this suggest that possibly the reason for low intercorrelations, the high specificity, discovered by the Minnesota group is the fact that most of the tests used by them are actually little more than motor tests, and that their "*m*" is really pretty much the same "factor" as that which Seashore claims to measure—a constellation of highly specific motor skills? May we not look here for the fundamental difference between Minnesota's "*m*" and Cox's?

A priori there would appear to be four phenomena which one should distinguish in dealing with mechanical activities:

1. Specific motor skills per se (as indicated by Seashore);
2. Manipulative or mechanical ability (which the Minnesota group sought to measure. It is not, according to Cox, the same as the "practical ability" suggested by Macfarlane);
3. Mechanical aptitude (an intellective activity involving the ability to educe space relations between objects, without necessitating their prehension and manipulation); and finally,

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* *Cf.* Seashore's uncorrected intercorrelation of .25.

† It is appreciated that in every case there are only two manipulation tests to correlate. The suggestion contained in this argument is nevertheless sustained.

4. The sheer intellective factor, labelled "*g*" by Spearman, which presumably pervades all cognitive activity, including the mechanical.

The Minnesota group seems to have got some of these concepts confused. From the point of view of internal consistency its battery would appear to be far superior to Cox's. In so far as its best battery of tests (not only mechanical) correlates high (about .8) with a criterion of excellent reliability (about .95) it is probably perfectly satisfactory as a measure of skill in shop-work performed by junior high school boys. The study is splendidly watertight. But, in view of the above arguments, one wonders whether its assumptions are entirely warranted. Cox's position, at least in theory, appears to be the more securely tenable. His tests are consistent in that they deliberately exclude motor and manipulative activity in their immediate solution; and in that, before finally determining the organization of "*m*," Cox eliminates (or claims to have eliminated) the influence of "*g*" from his tests.

On the other hand, Cox's material is vague and often exceedingly unsatisfactory. His populations are heterogeneous (by comparison with those of the group study) and most of them too small. The same tests have not been used on all groups alike. And one is left with an uncomfortable suspicion that success in answering his tests (no scoring procedure has been indicated) depends to such an extent upon verbal intelligence, that "*m*" (even when, to all intents and purposes, the influence of "*g*" has been eliminated) still contains a powerful amount of "*g*."

It might be an interesting piece of research to analyse in terms of the tetrad difference technique the data obtainable from a homogeneous group in response to (*a*) a test of verbal intelligence, and (*b*) a combined battery including tests such as (1) the Minnesota assembly and spatial relations tests (for "mechanical ability"); (2) a selected group of Cox's models, explanations, etc. (for "mechanical aptitude"); and (3) either the Minnesota tests for steadiness, card-sorting, packing blocks, and tapping, and Link's machine operators' test, or some form of motor skills battery, similar to that developed by Seashore (for "motility").

Cox and the Minnesota group have demonstrated how such an investigation can be conducted. Possibility an experiment along the lines here indicated might help to clear up the basic issues involved in their major disagreement.

THE RELATIVE EFFORT OF CHILDREN OF NATIVE *VS.* FOREIGN BORN PARENTS*

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INTRODUCTION

The problem here attempted is to determine by objective means the relative effort of children of native *vs.* foreign born parents. The interest in this study grew out of recognition of the tendency to discriminate against the foreigner in the manner which he applies himself in accomplishing school tasks. The significance of such an experiment may be more fully appreciated when we stop to consider that approximately one in every eight, or thirteen per cent, of the population of the United States is of foreign birth.

The AQ, or Accomplishment Quotient, is used as the index to effort. The AQ is the EQ (educational quotient) divided by the IQ (intelligence quotient). Quoting from the Twenty-First Yearbook,[1] † "The IQ is a measure of the native ability of the child and shows his potential rate of progress. The EQ is a measure of the educational attainment of the child and shows his actual rate of progress. The Accomplishment Quotient is the degree to which his actual progress has attained to his potential progress by the best possible measure of both. It is a mark which evaluates the accomplishment of the child in terms of his own ability." Franzen[2] states, "Since the IQ is the potential rate of progress and the EQ is the actual rate of progress, the ratio of the EQ to IQ gives the percentage of what the child could do, that he has actually done. This would be a mark of the child's effort, a mark of concentration and interest that the child has in school work, and so far as no other inherited traits than intelligence affect school work it is a measure of the efficiency of a child's education thus far. If there are such other innate bases it is also a measure of inherited traits, such as concentration and effort. At any rate, it is a measure of the child's accomplishment, and so of the effort and concentration as they really are at present working under those school conditions." Witty and Lehman[3] defining the AQ say, "The AQ

* The writer is indebted to Professor James P. Porter of Ohio University for guidance in this study.

† Numbers indicate reference in bibliography.

is a comparison of the EA (educational age) to the MA or the EQ to the IQ. Deviations above and below 1.00 indicate the extent to which effort is expended and ability exercised in the tasks of the school. Presumably an AQ of a 1.00 indicates that the mental ability and the educational attainment of the child or group are developing coordinately."

Goodenough[4] reminds us that immigrant groups and their immediate descendants differ markedly in their performances on the ordinary type of intelligence test. She suggests two theories to account for these differences. The first ascribes the inferior showing to such postnatal factors as inferior environment, poor physical condition, and linguistic handicaps. The second recognizes to some degree the effect of these factors on test-results, but holds that it is impossible to account for all the facts which have been observed upon any other hypothesis than that of innate differences. She goes on to say, "Although a test is completely independent of language, the rank order of various racial groups corresponds very closely to the results of other investigations using verbal tests."

Many experiments have been undertaken and reported relative to the linguistic handicap with which the foreigner is faced when he takes a test designed to measure all children but has been standardized on English speaking groups.

Brown[5] has made an investigation on retardation in several schools in northern Michigan. He found there was a wide variation in retardation among the children of different nationalities. It was revealed that after a pupil of foreign born parents had attended an American school for one or two years, he tested as high by employing the English language as by using the native tongue.

Young[6] in a study carried on in the San Jose schools in which he used the Army Alpha and Beta Tests on American, Italian, Portuguese, and Spanish Mexican children, found that the Alpha Test proved a better measure of the Latin groups than the Beta. He concluded that language handicap was not the cause of school difficulty.

Jones[7] made a comparison of the scores on the Myers Mental Measure and the McCall Multi-Mental Scale, discovering there was no appreciable difference between the scores made by the natives and those made by the foreign. It is contended that the former test is largely non-verbal while the latter is highly verbal.

A statement from the Twenty-Seventh Yearbook by Burks and Kelley reads,[8] "We find studies that purport to measure the effect of

language handicap on verbal intelligence test scores by comparing the mental ages of foreign children earned on verbal and non-verbal intelligence tests. The mental ages of children of certain low testing nationalities commonly turn out to be closer to the norms of American children when measured on non-verbal tests than when measured on verbal ones. But in as much as verbal and non-verbal test scores, even for American children, seldom correlate with one another higher than .6 or .7, it is obvious that, although both types of test are called 'intelligence' tests, they measure about as much not held in common as they measure of what is held in common. Hence, it is not legitimate to infer from such data alone that language handicap accounts for the low scores of the foreign children on verbal tests."

Although further investigations will be necessary to settle the question, the foregoing citations have some significance. May it not be reasonably assumed that some personality trait such as effort is playing an important rôle?

Methods and Procedure

The schools selected for making this study are located in mining communities of Athens County, Ohio. Approximately ninety-five per cent of the workers are employed in the mines. Under normal conditions the economic situation is generally good. Due to a strike which has lasted for over a year a severe depression has developed. For the most part, foreign standards of living prevail. The church and school are the chief sources of culture.

The groups under consideration consist of the children from the fourth to the eighth grade. See Table I for a detailed statement of nationalities. Those whose parents are foreign born constitute the one group and those children whose parents are native born make up the other group. All children were born in America, but the majority hear a foreign language at home. The pupils of both groups are of much the same social status. Arlitt[9] emphasizes the importance of taking this factor into account. She finds there is a marked difference in the distribution of intelligence in groups of children of the same nationality but of a different social level.

It was recognized at the outset that there was a selected group of natives. Goodenough[4] remarks that a person of low intelligence tends to gravitate to those neighborhoods where the economic requirements are minimal; and, once there, he reacts toward his surroundings along the line of least resistance. From personal observation and inquiry

it was learned that no prejudice or favoritism existed on the part of the teachers. The native and foreign were treated alike.

The hearty cooperation of the teachers and principals was had throughout. The pupils manifested a great deal of interest in the tests by giving close attention to all instructions and suggestions of the examiner.*

The tests used were the Otis Classification Forms A and B, and special tests of the sentence completion and auditory memory type.

TABLE I.—DISTRIBUTION OF NATIONALITIES

NATIONALITY	No. of Cases
School *A*	
American	65
Hungarian	23
Polish	24
German	6
French	13
Italian	3
Slavish	4
Lithuanian	2
Foreign	75
Native	65
Total	140
School *B*	
American	98
Hungarian	45
German	4
Polish	1
Foreign	50
Native	98
Total	148
School *C*	
American	68
School *D*	
American	43

* Most of these pupils were accustomed to taking standardized tests. Form A of the National Intelligence Test and Forms A and B of the Stanford Achievement Test were given the preceding year in an effort to determine the influence of special intensive training in various school subjects. While the results, when considered from the point of view of this study tend to confirm the findings here reported it has seemed best to omit further mention.

The general procedure was to administer the first form of the test; then after a period of a few weeks give the second form of the same test.

The problem naturally divides itself into two distinct approaches, each of which will be considered separately.

Test Findings—Part I

In attempting to determine effort by using the AQ as an index, it was decided that the Otis Classification was the best examination available, in that, it is composed of both the so-called educational and mental ability tests. The first form was given in January and the second in April. The AQ for each individual on each test was derived

Table II.—The Median EQ, IQ, and AQ for the Four Schools on Form A of the Otis Classification Test, also Quartile Range for the AQ

School	EQ	IQ	AQ	Quartile range of AQ
C	82.77	86.81	95.35	7.08
D	82.91	80.83	96.94	6.02
A (Native)	86.78	86.54	99.42	6.88
A (Foreign)	84.5	74.8	103.28	7.39
B (Native)	79.54	81.59	94.62	6.49
B (Foreign)	83.12	81.36	100.83	7.66

in the way previously stated. Only results from those pupils receiving both forms are considered. The different grades in Schools *A* and *B* were highly comparable in numbers of each sex, and in relative numbers of foreign and native.

The reason for giving the two forms was for the purpose of checking the consistency of the two groups in achieving school work within the same limits of time.

Schools *C* and *D* were selected and tested to see if the absence of the foreign affected the academic achievement of the native as determined by these tests.

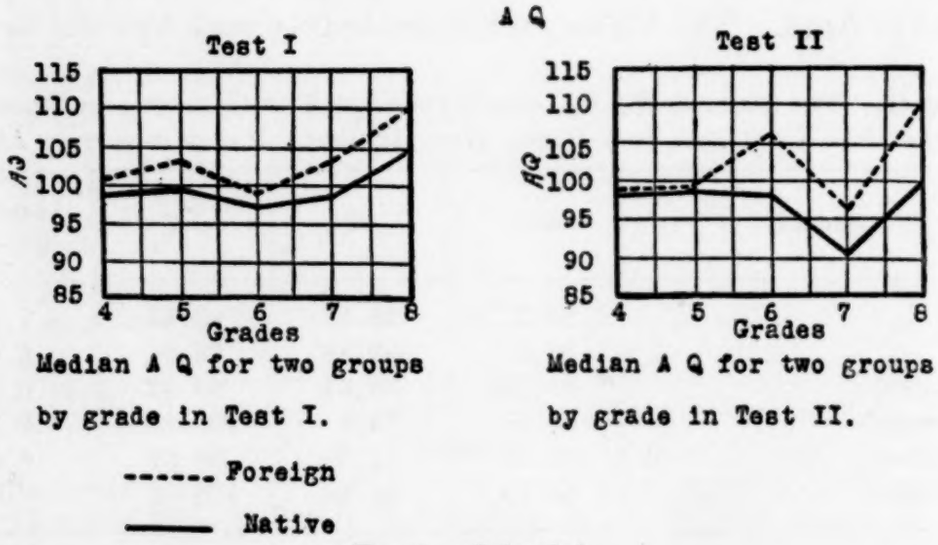
Table II gives the median EQ, IQ, and AQ, for the different schools and groups. The quartile range is also given for the AQ. In Table III are the same data on the second test.

In Fig. 1 and 2 are given the curves for the median AQ on the two tests for the two groups by grade.

TABLE III.—THE MEDIAN EQ, IQ, AND AQ FOR THE THREE SCHOOLS ON FORM B OF THE OTIS CLASSIFICATION TEST, ALSO QUARTILE RANGE FOR THE AQ*

School	EQ	IQ	AQ	Quartile range of AQ
D	80.83	84.64	93.86	7.03
A (Native)	88.75	92.75	97.5	6.69
A (Foreign)	88.05	87.81	100.68	8.14
B (Native)	84.37	88.84	95.	6.02
B (Foreign)	88.57	87.	102.5	7.75

* As School *C* had dismissed for the summer the second test could not be given



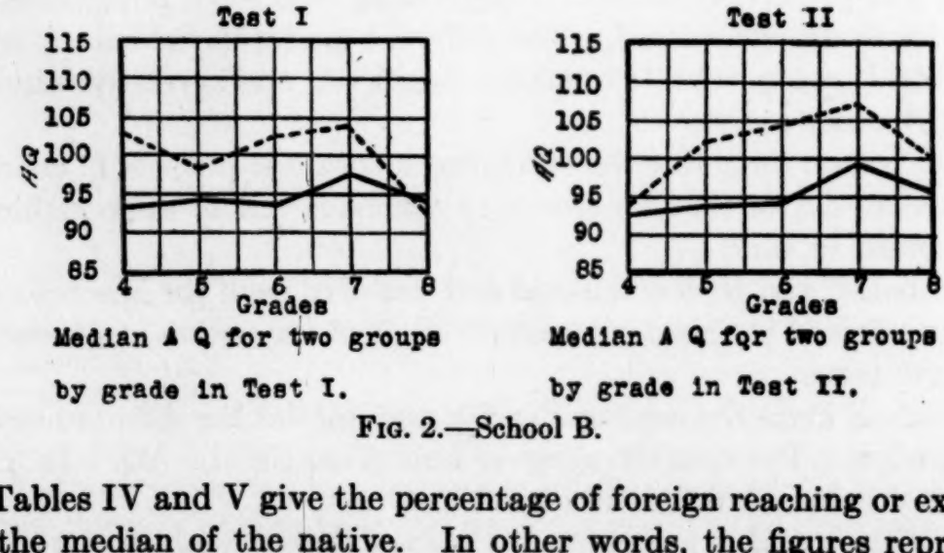
Median A Q for two groups by grade in Test I.

Median A Q for two groups by grade in Test II.

------ Foreign

——— Native

FIG. 1.—School A.



Median A Q for two groups by grade in Test I.

Median A Q for two groups by grade in Test II.

FIG. 2.—School B.

Tables IV and V give the percentage of foreign reaching or exceeding the median of the native. In other words, the figures represent how many foreign are as good as or better than half of the native.[11]

If the percentage is greater than sixty or less than forty it may be considered significant. Starch[12] states that any differences lying between forty per cent and sixty per cent of the number of either

TABLE IV.—THE PERCENTAGE OF FOREIGN REACHING OR EXCEEDING THE MEDIAN OF THE NATIVE ON FORM A OF THE OTIS CLASSIFICATION TEST

School *A*					
Grade	4	5	6	7	8
EQ	33.3	65.	23.	47.	50.
IQ	33.3	65.	30.7	35.2	10.
AQ	73.3	60.	76.9	82.3	70.
School *B*					
EQ	75.	66.6	46.	75.	33.3
IQ	100.	80.	23.	50.	33.3
AQ	87.5	86.6	84.6	75.	83.3

TABLE V.—THE PERCENTAGE OF FOREIGN REACHING OR EXCEEDING THE MEDIAN OF THE NATIVE ON FORM B OF THE OTIS CLASSIFICATION TEST

School *A*					
Grade	4	5	6	7	8
EQ	40.	65.	30.7	41.1	60.
IQ	26.6	75.	38.4	17.6	10.
AQ	66.6	50.	69.2	82.3	80.
School *B*					
EQ	87.5	80.	61.5	50.	33.3
IQ	75.	66.6	38.4	50.	16.6
AQ	87.5	100.	84.6	62.5	66.6

group reaching or exceeding the median of the other are practically negligible. If sixty per cent of one group reach or exceed the median of the other it means that ten persons in a hundred of the one group, are by a small amount superior to the other.

TABLE VI.—THE PERCENTAGE OF FOREIGN REACHING OR EXCEEDING THE MEDIAN OF THE NATIVE ON FORMS A AND B OF THE OTIS CLASSIFICATION TEST

	Form A	Form B
All foreign in school *A*:		
EQ	49.3	57.3
IQ	44.	45.3
AQ	80.	66.6
All foreign in school *B*:		
EQ	68.	74.
IQ	56.	58.
AQ	86.	68.
Foreign in *A* and *B*:		
EQ	41.6	58.4
IQ	52.	42.4
AQ	76.	67.2

PART II

The central problem is here approached from a different angle than the preceding experiment. Special tests were devised after Sentence Completion and Auditory Memory Tests of Otis. The first type of test is made up of sentences from a given story with words or phrases omitted. It is the pupil's task to fill in these blank spaces with appropriate words that he may have a rather complete story when he has finished. A list of possible words follows each set of seven or eight sentences. For example: Once_____was a terrible giant ogre.

pleasantly	fiercely	there
their	crawl	sitting
story	terribly	built
died	lived	pass

The best word is *there*, consequently it is placed in the blank space. It will be recalled that the second type of test depends on the ability of the pupil to retain and recall events mentioned in a story which he hears read. For example: Was Gotham known for its wondrous wise men? (yes, no, didn't say). The correct response is "yes" according to the story, therefore this word is underscored.

There were two sets of these examinations: the first set was given on April 12 and the second on April 26.

TABLE VII.—MEDIAN SCORES FOR THE NATIVE AND FOREIGN ON THE SENTENCE COMPLETION AND AUDITORY MEMORY TESTS

	Foreign		Native	
No. of examination	1	2	1	2
Completion tests	12.22	14.	15.19	14.25
Memory tests	14.06	15.38	15.53	14.72

Percentage of foreign reaching or exceeding the median of the native.

No. of examination	1	2
Completion tests	35.2	41.1
Memory tests	73.5	73.5

The Completion and Memory Tests had thirty-five questions or statements each. The score was the number answered correctly.

At the close of the first test the pupils were told that in two weeks the examiner would be back to give them a similar set of questions

TABLE VIII.—MEDIAN SCORE FOR THE NATIVE AND FOREIGN ON THE TWO EXAMINATIONS IN THE SEVENTH GRADE

	Foreign		Native	
No. of examination	1	2	1	2
Completion tests	12.	14.16	17.	17.5
Memory tests	13.85	16.25	16.25	16.25

Percentage of foreign reaching or exceeding the median of the native in the seventh grade.

No. of examination	1	2
Completion tests	37.5	62.5
Memory tests	43.7	62.5

and incomplete sentences. They were advised that the stories from which these tests would be compiled were to be found in specified books in their library, and that from the six stories the names of which

were placed on the board, two would serve as the basis of the second examination. No further suggestions were given. The teachers were requested to make no further mention of the work.

Table VII gives the results for the two groups in the two examinations. Table VIII gives the results for the two groups on the two examinations for the seventh grade, the reason for selecting this particular grade being that there were the same number of the foreign and native.

Discussion and Conclusions

When Colvin[13] compared the scores earned, on the Otis Group Intelligence Scale, Forms A and B, by children of Brookline, Massachusetts and Cincinnati, Ohio he found the latter to be inferior. He attributed this inferiority to differences in opportunities to learn words and acquire skill in their use. He supported his conclusion with the fact that the children in the poorer localities in Brookline did not score as high in the entire test as did the children in the more favored localities. In the Arithmetic test "largely non-verbal in its nature" the scores were not inferior to those made by the children in the better sections.

The results of our own study would seem to support Colvin's contention. The scores on the entire test were lower than the established norms. However, upon a careful examination of the Arithmetic problems of the Otis Classification it was found that both groups did equally well. In view of this fact it is apparent that both groups were competing on an approximately equal basis with reference to the language factor. In no case was it discovered that the foreign were more handicapped linguistically than the native.

From Tables II and III it may be observed that in all cases the foreign make a higher median AQ than the native. It is true that the native make a higher IQ but the difference is so slight that we can attach little, if any, significance to it.

From these results it is evident that the native are more highly selected than the foreign, the quartile range in AQ is greater for the foreign group. Inspection of frequency distribution tables also shows greater variability. The selection of the native is emphasized by the fact that nearly fifteen per cent of those taking the first test had moved from the community by the time of the second. This accounts for the limited number of cases in the study, as we considered only those pupils who were tested both times.

The schools in which no foreign were found, tested on a par with the other two schools. That there were no foreign in Schools *C* and *D* was learned from questionnaires filled out by the pupils and confirmed by the teachers. An attempt was made to get information on the different grades with reference to median AQ. Figures 1 and 2 show a great deal of fluctuation, but it will be noted that the foreign and native groups align themselves in curves exhibiting marked consistency.

The eighth grades of Schools *A* and *B* were very small. Table IV and V present data which might lead one to conclude that the low IQ of the foreign was responsible for their high AQ. Where this difference occurs the probable explanation is the smallness of the class.

Table VI shows the percentage of foreign reaching or exceeding the median of the native to be at least significant.

In approaching the problem by the second method, the Special Completion and Memory Tests, it was assumed that the group showing the most improvement would be putting forth the most effort. This assumption could be reasonably justified on the basis of the preceding experiment. Tables VII and VIII would indicate the foreign to be superior. Interesting details in connection with this second experiment are: Of seven who were effortful enough to read the stories for the second examination, five were foreign; the correlation between the two examinations was .794 with a PE of .032.

Our study may have something in common with an investigation which has been carried on by Miller[14] with freshman engineering students at the University of Michigan. "The low students are, in the main, children and grandchildren of American-born men and women. They also are the sons of the better educated and more prosperous parents. A surprisingly large percentage of the high students are the grandsons of foreign-born men and women. They are the sons of parents having little education or none. In the main they are the sons of parents whose education does not include the high school. Twenty-four per cent are the sons of parents who had less than a grammar school education." He further states: "Low students are lacking in the quality of vision, powers of analysis and coordination. They are superficially bright and ingenuous, but their tenaciousness of purpose and capacity for sustained mental effort are so low that their curve of effort has a steadily downward trend."

May not the above discussion and our findings suggest a possible and partial explanation for the prevailing opinion of the thrift and rapid economic rise of the foreigner?

Some conclusions to be drawn from this study may be briefly stated as follows:

1. Groups of children of foreign-born parents are consistent in making higher median Achievement Quotients than are groups of children of native-born parents.

2. In most cases the median Intelligence Quotient is slightly higher for the groups of native children than for the foreign.

3. Both groups were handicapped in the use of language as measured in all the tests.

4. The foreign have little or no inhibiting or unfavorable influence on the school progress of the native.

5. By the use of objective tests the foreign prove themselves superior to the native in effort. The relative significance of this personality trait is at least suggested by the manner in which the foreign overcome obstacles in making new adjustments.

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THE EFFECT OF THE FORM OF A COMBINATION IN THE LEARNING OF A MULTIPLICATION TABLE BY BRIGHT AND DULL CHILDREN

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In an experimental study reported elsewhere,[1] selected groups of fifteen children each, learned a multiplication series from 2×67 to 9×67, inclusive. Practice was provided by a card, upon which the eight combinations appeared in both vertical forms, that is as $\underline{\begin{matrix}67\\2\end{matrix}}$ and $\underline{\begin{matrix}2\\67\end{matrix}}$, with the answers given at the bottom of the card in both horizontal forms, that is, as $2 \times 67 = 134$, and $67 \times 2 = 134$. The children read the combinations above orally, and found the answers by looking below and giving them orally. The subjects were selected by individual test with the Stanford Revision of the Binet and by chronological age. Half of them were practically nine years old and half twelve. Half of each of these ages were of IQ's between eighty and ninety, and the others between one hundred ten and one hundred twenty. Full description of the subjects and the technique of the experiment are given in the reference cited above.

The table shown herewith gives the record of the correct answers of each group. A striking likeness is seen in nearly every pair of the combination forms. In only four cases are the differences in the scores of pairs more than five. Investigation of the detailed records indicates that these are purely chance results, explainable in the small number of responses in certain instances and the cumulative effect of very few subjects in small scores.

The main point of interest in these data seems to be not so much that, in learning the answers, the two forms of an arithmetic combination are of no particular difference in difficulty, as that there seem to be no distinguishing differences in that regard between children of rather low mental ability and others of rather high mental ability. In effect it seems to suggest that the learning process, whatever it may be in ultimate elements, is much the same for dull and bright. This is supported by other evidence in the table not stressed in this report because it has been treated more extendedly elsewhere, namely, that

[1] Wilson, F. T.: "The Learning of Bright and Dull Children." Teachers College Contributions to Education, No. 292, 1928.

the combinations which were hardest for the bright were also hardest for the dull, and that the combinations easiest for the dull were also strikingly easiest for the bright.

These points tend to turn the interest of those concerned with the guidance of learning processes of human beings to two concepts said to be at present of some psychological repute. They are, first, that human beings, despite great variations in abilities and interests, learn

TABLE I.—NUMBER OF CORRECT RESPONSES TO EACH FORM OF THE COMBINATIONS BY THE DULL AND BRIGHT GROUPS

Combinations	Dull 9	Bright 9	Dull 12	Bright 12	Total
2 × 67.....	21	93	99	118	331
67 × 2.....	22	98	92	118	330
3 × 67.....	31	74	73	102	280
67 × 3.....	20	74	71	101	266
4 × 67.....	1	14	2	20	37
67 × 4.....	0	17	3	17	37
5 × 67.....	43	85	76	101	305
67 × 5.....	44	82	72	110	308
6 × 67.....	28	63	35	56	182
67 × 6.....	28	62	43	61	194
7 × 67.....	0	13	10	21	44
67 × 7.....	0	13	9	23	45
8 × 67.....	7	44	23	58	132
67 × 8.....	7	49	18	53	127
9 × 67.....	29	95	58	89	271
67 × 9.....	31	99	61	86	277
Total.....	312	975	745	1134	3166

in much the same way one to another. There are differences in rate, accuracy and retentiveness of learning, but basically there seem to be conditions and progress of like kind. The second concept is that a learning task such as this is attacked and progress made in it in a way which suggests the unity or wholeness of the entire matter, rather than a separateness of parts. Grasping the plan of the task, as expressed in an answer, the mind seems not to be disturbed, perhaps, by the arrangement of parts, but seeks to handle the material as a whole.

STUDY HABITS OF TEACHERS COLLEGE STUDENTS

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The question of the amount of time given to study is of importance to both the student and to the administrator. Students in a teachers college, preparing to guide others in learning, need especially to demonstrate to themselves the relationship which exists between their study habits and their scholastic achievement. From the administrator's standpoint anything approaching successful student guidance cannot be attained without definite information in regard to study activity and the relation it bears to intelligence and scholastic standing.

In this investigation we sought to answer these questions: When do students study? How long do they study? What is the nature of their study activity? How is the amount of study time related to intelligence and scholarship?

Students in General and Educational Psychology classes were used as subjects. The investigation was conducted during the school year 1928–1929. A total of one hundred twenty-seven students kept daily records of their study time for twenty-eight days. Recording was not begun until after the third week of each semester. Keeping the records was considered a part of the regular work of the courses. Every effort was made to secure the cooperation of the students since this type of investigation depends so much upon it. The instructor took one-half hour of the period on the day that the record blanks were given out to explain the purpose of the investigation and to show them the importance of keeping the records carefully. Each succeeding week when new blanks were given out the students were again urged to keep the records faithfully.

The study record consisted of a specially prepared sheet on which columns were provided wherein the student recorded each day's study activity. The students were given sufficient record blanks for one week. At the end of the week they turned in their records and got a new set of blanks. Columns were provided in which the students could record the following information: Time of study—the day of the week and whether it was done in the morning, afternoon or evening; type of study—whether reading in a textbook, outside reading assignments or written work such as themes and problems.

The study day was divided into three periods: Morning, from time of arising until twelve noon; afternoon, from twelve noon until six o'clock; evening, from six o'clock until time of retiring.

During the school year all the students were given the American Council of Education Psychological Examination. Reports were secured from the registrars office of the grade points earned by each student in all subjects for one semester. Correlations were computed between study time, scholarship and intelligence.

Results

From analysis of the 3556 days of study reported by the group, as shown in Table I, there was a total of nearly 395,000 minutes, 6583 hours, given to study by the entire group over the period of four weeks. This would be an average of one hundred eleven minutes, or just short

Table I.—Time of Day When Study Was Done

Time of day	Number of minutes	Per cent	Average number minutes per student, per day
Morning	96,493	24	27
Afternoon	125,157	32	35
Evening	173,348	44	49
Total	394,998	..	111

of two hours per day for each student. Twenty-four per cent of the total study work was done in the morning period, thirty-two per cent in the afternoon, and forty-four per cent in the evening. The results indicate that nearly one-half of the students' studying is done in the evening by artificial light. The average number of minutes per student per day for the morning period is twenty-seven minutes, for the afternoon thirty-five minutes, and for the evening period forty-nine minutes. These averages assume that all students studied on each of the twenty-eight days that the investigation covered.

A comparison of the study activity on the various days of the week is recorded in Table II. The number of minutes recorded for any given day is the sum of all the study time reported by all the students for that day. There is a gradual increase in the amount of study from Sunday to Tuesday where it begins to drop off to Thursday. From Thursday to Sunday there is a pronounced drop. The most outstand-

ing drop is from Thursday to Friday when less time was given to study than on any other day of the week. The difference between Saturday and Friday is not as much as one might have supposed.

In the second column of this table the average number of minutes per day for each student is reported. In these averages the actual number of students studying on a given day is taken into consideration. In Table I where the number of students studying on a given day was not taken into account, it appeared that, on the average, our students were studying one hour and fifty-one minutes per day. In Table II those who did not study were eliminated from the averages and the mean increased to two hours and thirteen minutes.

TABLE II.—COMPARISON OF STUDY ACTIVITY ON VARIOUS DAYS OF THE WEEK

Days of week	Number of minutes	Daily average, number of minutes per student	Number of students studying	Per cent
Sunday	43,890	128	343	67
Monday	66,733	140	476	94
Tuesday	83,488	168	505	99.4
Wednesday	72,881	148	488	96
Thursday	69,293	140	496	97.6
Friday	33,496	92	374	73.6
Saturday	25,217	116	213	41

The number of students studying on a given day is reported in column three of Table II. This represents the total for the four week period. Thus if all the students had studied on a given day the Number of Students Studying would have been five hundred eight since there were one hundred twenty-seven students who kept records for four weeks. In the fourth column the per cent of students studying on any given day is shown. In general the number of students studying shows about the same tendency to increase or decrease that the number of minutes shows. However, there are interesting exceptions to this. The number of students engaging in study increased from Wednesday to Thursday, but the duration of the study periods decreased. There is a greater number of students studying on Friday than on Sunday, but the total number of minutes given to study on Sunday is twenty-four per cent greater than that on Friday. There is a general tendency to decrease the length of the study period

as the week-end approaches. A comparatively small number of students, forty-one per cent, are studying on Saturday, however, their study activity seems to be of a better quality than Friday's in as much as it is carried on for longer periods of time. Both from the standpoint of the number of students studying and the average length of time given to study, Tuesday tends to be the best day of the week for study.

Book,[1] in a recent investigation of reading among college students states that it has been estimated that the average student gets ninety per cent of his information in college from some type of reading activity. In Table III evidence is presented which apparently sub-

TABLE III.—COMPARISON OF AMOUNT OF TIME GIVEN TO READING AND WRITING IN STUDY ACTIVITY

Reading activities				Writing activities			
Textbook		Collateral		Problems		Papers	
Number minutes	Per cent	Number minutes	Per cent	Number minutes	Per cent	Number minutes	Per cent
100,886	63	30,530	19	13,552	8.5	14,289	9.5

stantiates this estimate. Not all the students signified the type of study, whether reading or writing, and hence our data represent the reports of only those who did. The total number of minutes for those students who signified the type of study was 159,257. Of this, sixty-three per cent was given to reading textbooks; nineteen per cent to reading collateral material; 8.5 per cent to working problems; and 9.5 to writing papers and themes. Eighty-two per cent of all the study time was used in some type of reading activity and eighteen per cent in writing work. This is, of course, only a rough estimate since some types of study are difficult to classify under the above headings.

Since some students carry heavier scholastic loads than others it was necessary to devise a means of equalizing this difference before determining the average study time for a given student to be used in our correlations. This was accomplished by finding the average number of minutes per week spent in study and then dividing this by the number of units or hours carried for the semester. This gave the number

[1] Book, Wm. F.: How Well College Students Can Read. *School and Society*, Vol. XXVI, August, 1927, pp. 242–248.

of minutes studied for a given hour of school work. Courses which did not require preparation, such as physical education activities, were eliminated. When the student's grades and study time were correlated the Pearson r was $+.317 \pm .05$. The coefficient, when grades were correlated with intelligence, was $+.565 \pm .04$. Intelligence correlated with study time $+.003 \pm .06$. The first two coefficients are approximately the same as secured by May[1] in an earlier study of this same character. However, he secured a negative correlation between intelligence and study time. Using the partial correlation method and holding intelligence constant, the correlation between study time and scholastic standing is $+.382 \pm .05$.

From these coefficients it would seem that the intelligence test was a better indicator of scholastic success than study time. Intelligence is not definitely related to study time since the student with a high or low score is as likely as not to study a long or short period of time. This is illustrated by reference to an individual case. Two students who stood at the ninety-eighth percentile in the intelligence test studied, on the average, seven minutes, and four hours and nineteen minutes per day respectively. The student whose study time was seven minutes per day made a C average in her courses. The other student had a straight A average.

Summary

An investigation was carried on with one hundred twenty-seven teachers college students of freshman to senior standing to analyze the time factor in study and to relate it to intelligence and scholastic standing. The following points of interest have appeared:

1. Approximately one-half, forty-four per cent, of the students' study is carried on in the evening by artificial light.
2. Tuesday tends to be the day on which the most studying is done; Friday is the day when the least studying is done.
3. Sunday is a better study day than either Friday or Saturday, judged in terms of amount of time devoted.
4. The average daily study time for the entire group was one hour and fifty-one minutes. When those who did not study on a given day are eliminated this average rises to two hours and thirteen minutes.

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[1] See May, Mark A.: Predicting Academic Success. *Journal of Educational Psychology*, Vol. XIV, 1923, pp. 429–440.

5. Towards the end of the week there is a pronounced tendency to shorten up on the duration of the study periods and a less pronounced tendency for fewer students to be studying.

6. Sixty-seven per cent of the students studied on Sunday, ninety-four per cent on Monday, over ninety-nine per cent on Tuesday, ninety-six per cent on Wednesday, ninety-seven per cent on Thursday, seventy-three per cent on Friday, and forty-one per cent on Saturday.

7. Sixty-three per cent of the students' study time was given to reading textbooks; nineteen per cent to outside readings; 8.5 per cent to working problems; and 9.5 per cent to writing themes and other papers. Eighty-two per cent of the total time was used in reading and eighteen per cent in writing.

8. ~~Study time correlates $+.317 \pm .05$ with scholastic standing; intelligence correlates $+.565 \pm .04$ with scholastic standing, and intelligence correlates $+.003 \pm .06$ with study time. With intelligence held constant, study time correlates $+.382 \pm .05$ with scholastic achievement.~~ Intelligence appears to be a better indicator of scholastic success than study time.

CONSTANT CHANGES IN THE STANFORD-BINET IQ

PSYCHE CATTELL

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The Harvard University Growth Study, conducted by Professor Walter F. Dearborn, is now in its ninth year. Each year some one hundred fifty to two thousand of the children have been given an individual Stanford-Binet intelligence examination. By the end of the seventh year two or more Binet IQ's had been secured for one thousand one hundred eighty-three pupils. These one thousand one hundred eighty-three subjects were divided into groups according to the period of time that had elapsed between the first two Binet examinations: under three months, three to six months, six to twelve, twelve to eighteen, eighteen to twenty-four, twenty-four to thirty-six, thirty-six to forty-eight, forty-eight to sixty and sixty to seventy-two.[1]

The median amount by which the second IQ fell short of or exceeded the first is shown in Table I. It appears probable that the median

TABLE I.—MEDIAN BINET IQ CHANGES AFTER VARYING INTERVALS OF TIME

Months between tests	No. of cases	Median differences	PE
0– 3	18	+5.0	±1.1
3– 6	54	+3.8	±0.8
6–12	308	+0.2	±0.4
12–18	174	+2.0	±0.6
18–24	64	−0.5	±0.9
24–36	92	−0.2	±0.9
36–48	293	−2.7	±0.4
48–60	51	+1.0	±1.5
60–72	329	−0.1	±0.4
0–72	1383	−0.02	±0.22

gain of 5.0 points in the group repeating the test within a period of three months and of 3.8 when repeating it after a period of from three

[1] It was found that the effect of practice did not carry over eighteen months, therefore a child that had been given several tests was used in more than one comparison provided that no test had been given between the two being compared or within a period of 18 months preceding the first. This procedure increased the number of comparisons by two hundred bringing the total up to one thousand three hundred eighty-three.

to six months resulted from the experience gained during the first testing. There, however, appears to be but little, if any, practice effect resulting from a test taken more than six months previous. The group of one hundred seventy-four cases with an interval of twelve to eighteen months made a median gain of 2.0 points, but the three hundred eight cases with an interval of 6 to 12 months showed a gain of only 0.2 of a point, from eighteen to twenty-four months there was a loss of 0.5 of a point.

In an earlier study it was found that at the upper levels of intelligence certain group tests gave uniformly higher and others uniformly lower IQ's than the Stanford-Binet.[1] The question arises as to whether this was caused by variations in the standards of one or both tests, by factors inherent in the test items, or since the group and individual tests were not always given in the same year, whether there was a real change in the relative intelligence level of the child.

When comparing the gains and loses of Stanford-Binet IQ's of bright and dull children, Garrison writes:

> Since there does seem to be a slight gain in the higher classes, it is evident that there is a slight practise effect, that the test is relatively easier in the higher ages, or that the IQ actually increases for the higher classes. We feel that there are not enough data available yet to warrant definite conclusions.[2]

Rugg and Carlton state that:

> Differences in retests will be approximately the same, irrespective of intelligence of the pupil.[3]

And Terman that:

> . . . the IQ remains almost equally constant for the three groups . . . The greatest tendency to gain appears with the average group and the next greatest with the dull. The differences, however are practically negligible . . . It makes little difference whether the child was bright, average, or dull, how long an interval separated tests or what the age of the child was at the earlier test.[4]

Each time-interval group was redivided into three IQ levels according to the average of the Binet IQ's: below ninety, ninety to one

[1] Cattell, Psyche: Comparability of IQ's Obtained from Different Tests at Different IQ Levels. *School and Society*, March 29, 1930.

[2] Garrison, C. S.: Additional Retests by means of the Stanford Revision of the Binet-Simon Tests. *Journal Educational Psychology*, May, 1922, p. 311.

[3] Rugg, Harold and Cecile Colloton: Constancy of the Stanford-Binet IQ as Shown by Retests. *Journal Educational Psychology*, Sept., 1921, p. 320.

[4] Terman, Lewis M.: "The Intelligence of School Children." Houghton Mifflin Co., 1919, pp. 140 and 146.

hundred nine, one hundred ten and higher. The median of the differences of each group are plotted in Fig. 1. The first bar of each group represents those with IQ's below ninety, the second those with IQ's from ninety to one hundred nine and third those of one hundred ten and above. The amount by which the median child's second IQ fell short of or exceeded the first is given on the vertical scale. For example, in the second group in which the time between the two tests varied from six to twelve months, the median pupil with an IQ below ninety lost 1.4 points, the median of those of average ability gained 0.1 of a point and the median of those with IQ's of one hundred

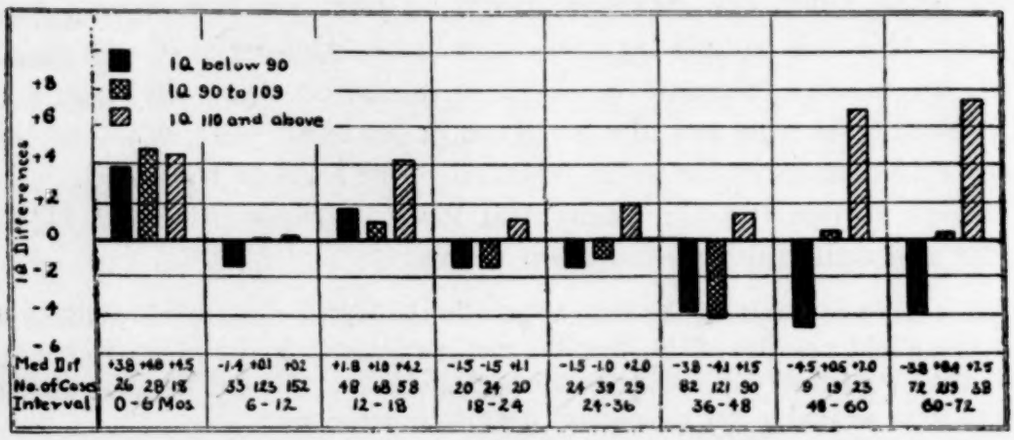

FIG. 1.—Median changes in the Binet IQ of dull average and bright pupils after varying intervals of time.

ten or higher gained 0.2. The same data are given in tabular form at the foot of the chart, the first row gives the median of the differences, the second the number of cases and the third the time interval between the two tests.

When the tests were repeated after an interval of less than six months the median IQ of the pupils at all three levels of intelligence showed a gain, probably due, as stated above, to the effect of practice. The average group gained slightly more than either the bright or dull group, but the differences are too small to be of significance. As the time interval between the tests is increased beyond eighteen months a tendency for the low IQ's to decrease and the high IQ's to increase becomes evident.[1] The further apart the two tests the more marked

[1] When a child passed a total of five or more tests in years sixteen and eighteen, Professor Terman's correction was applied to the mental age. (Genetic Studies of Genius, Vol. I, p. 42.) Since only a few of the children were over fourteen years of age at the time of the last test, the majority being under thirteen, the correction was needed in only a small proportion of the cases.

is the tendency. When the last two groups are combined it is found that the median loss of the eighty-one cases with IQ's of below ninety was four points while the sixty-one cases with IQ's of one hundred ten or higher gained seven points. The median change of those of average intelligence was only one-half of one point.

The tendency for the low IQ's to lose and the high IQ's to gain is shown even more clearly in Fig. 2. All these cases in which the interval

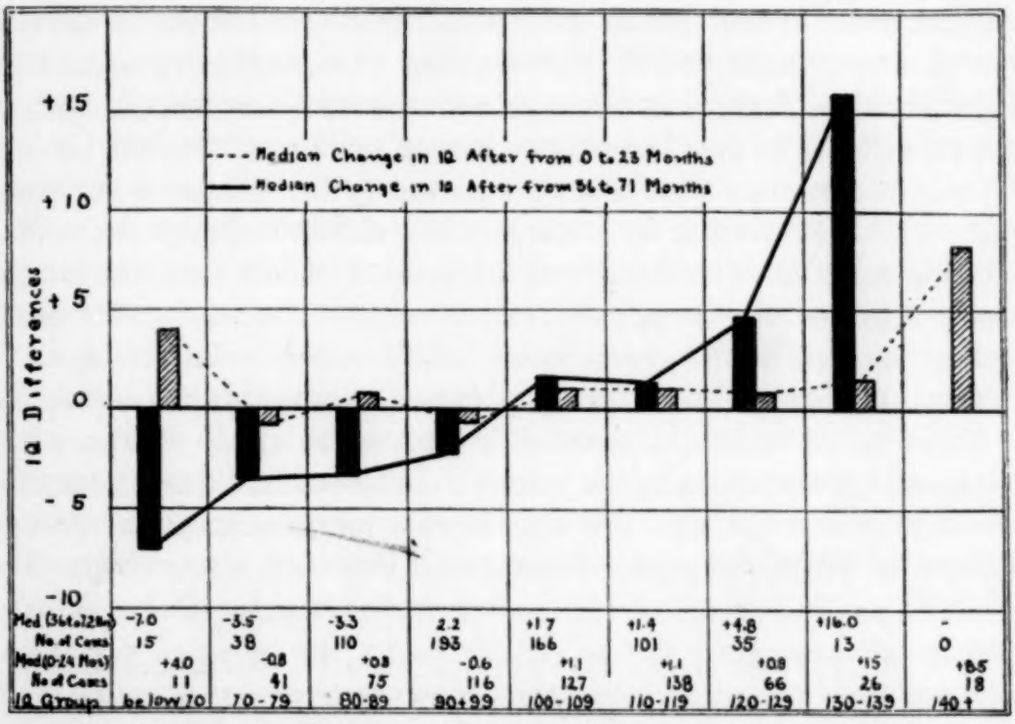

FIG. 2.—Median Binet IQ changes at different intelligence levels.

between the two Stanford-Binet tests was over three years were placed in one group and those with an interval of under two years in another. Within each group the subjects were divided into ten point IQ groups, leaving those below seventy in one group and those above one hundred forty in another. The medians of the differences between the first and second IQ of the pupils repeating the test after a period of from three to six years are represented by solid bars connected by a solid line. The tendency for the low IQ to become lower and the high IQ to become higher is marked. The lowest group lost 7.5 points, the highest gained 16.0, while the medians of the changes of the remaining groups ranged between these two extremes.

The median of the differences between the first and second IQ of the groups taking the two tests at intervals under two years gives a

different picture. They are represented in shaded bars connected by a broken line in Fig. 2. No group had a median change of more than 1.5 points with the exception of the group below sixty IQ and the one above one hundred forty. There are included seventy-two that took the two tests within a period of six months. The effect of practice carried over to the second test in these cases is probably sufficient to account for the excess of small gains over losses in the intermediate groups. The lowest group only contains eleven cases and the gains of four points may well be due to chance errors. The gain of nearly nine points in the group of eighteen cases with IQ's of one hundred forty and above is not so easy to explain, it may also be due, at least in part, to chance errors, or it may be that the effect of practice is carried over a longer period in the case of exceptionally bright children than it is among other children (only three of the eighteen cases were retested within a period of less than six months). Finally it is possible, though it does not seem probable, that the relative intelligence level of the group was actually raised during the short time between the tests. More than one factor is probably involved.

There is, of course, a possibility that some of the changes in IQ are caused by variations in the testers. Fifty-seven different examiners took part in the testing. All were instructors, assistants or graduate students in psychology or education at Harvard University. However, the general trend of the curves is too regular to be explained away by chance errors in the sample or by the personal equation of the examiners, it is more likely that such errors are responsible for the irregularities in the general trend.

The cause of the gain of the high IQ's and the loss of the low is not clear. The factor of practice is ruled out by the fact that the greater the time interval between the tests, the greater the gain of the bright pupils, and the fact that the pupils of low intelligence lost. The gain in the high IQ's would be accounted for if the upper tests on the Binet scale were too easy, but the reverse has generally been supposed to be true and, in any case, this would not explain the loss of the low IQ's. It may be that the bright child has, or finds, more opportunities to acquire that type of information which aids in successfully passing the Binet tests than the older child of the same mental age. The greater interest in reading of the bright child and the lesser interest of the dull child may be a factor.

If there is a tendency for the range in IQ's to increase with age it would be sufficient to account for the median increase of the high IQ's

and the decrease of the low IQ's. This seems to the writer the more probable explanation. It is, of course, well known that the range of the distributions of heights and weights of children increase as the age increases, also intelligence when measured in terms of mental age. The theory of the constancy of the IQ is based on the assumption that though the intelligence of the bright child increases at a greater rate than the dull child, that of both the bright and the dull child remain constant in proportion to his chronological age. A child that has a mental age 20 per cent above his chronological age at school entrance would maintain the same proportional difference between his CA and MA throughout the period of growth. Although the difference between his mental and physical age would increase, his IQ would remain constant.

The present findings indicate that those pupils that start school with IQ's above the average, not only increase in mental ability at a rate sufficient to keep the proportion between the life and mental age the same, but at a more rapid rate, causing the IQ to rise, while the dull child's mental age falls relatively to his CA, causing a drop in the IQ. This is contrary to the findings of Terman and of Rugg and Carlton quoted above but is corroborated by Garrison who finds a slight increase in the higher classes and with Cyril Burt, Doll and others who have found a decrease in the IQ of sub-normal children and with Kuhlmann who writes that:

> It has been known for some time that the IQ as found by tests that give correct mental ages at all mental levels does not remain constant throughout successive years, except for children with an initial IQ of 1.00. Initial intelligence quotients below 1.00 tend to decrease, and above 1.00 they tend to increase as the child grows older.[1]

Freeman in referring to sub-normal children makes the opposite statement:

> We may expect backward children to gain about as much from year to year and to continue to gain about as long as normal children or bright children.[2]

This would mean a marked increase in IQ of the backward children as age increases. It appears, however, from other statements made by Freeman that this is a slip of the pen and that what he had intended

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[1] Kuhlmann, F. and Rose Anderson: "The Forthcoming Revision of the Manual of Instruction for the Kuhlmann-Anderson Intelligence Tests." The Educational Test Bureau, Minneapolis, Minn., p. 118.

[2] Freeman, Frank N.: "Mental Tests." Houghton Mifflin, p. 357.

to write was probably that the dull child continued to grow as steadily and for as long a time as the normal and bright child, but at a slower rate. If this be the correct interpretation he is in agreement with the view held by Terman and his followers.

Conclusions

1. When a Stanford-Binet test is repeated within a period of three or four months the experience gained while taking the first test appears to result in a median gain of four or five points in the second IQ. No significant difference in amount of gain made by bright, average or dull children was found. The practice effect carried beyond six months appears to be insignificant.

2. A definite tendency was found for the pupils of high intelligence to gain and for those of low intelligence to lose in IQ as they become older.

SOME RELATIONSHIPS BETWEEN ALGEBRA AND GEOMETRY

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1. What is the relationship between ability in algebra and geometry?

2. What is the relationship between achievement in algebra and geometry?

3. What percentages of pupils show differences between algebra and geometry, in respect to ability and achievement?

4. Are the students who continue with geometry a more select group than all the pupils who took algebra?

5. Do students tend to get better or poorer grades in geometry than in algebra?

An attempt will be made to answer the above questions using data made available from two previous studies. Since these studies were conducted a year apart, and two of the schools were used in both studies, there were complete records in both algebra and geometry of one hundred eighty-one pupils. These records consist of scores on the Lee Test of Algebraic Ability[1] and the Lee Test of Geometric Aptitude[2] given before the pupils had begun the study of the respective subjects, scores on an algebraic achievement test[3] and on the Renfrow Geometry Test[4] given at the end of the first semester of each subject, and the first semester's mark in both algebra and geometry.

There has not been an attempt to follow-up each case that took algebra. There was loss through failures, drop-outs, and moving. Whether the pupils that moved would be selected from the upper or lower ranges of ability is not known, but the writers have assumed that the factor of moving has not caused a distortion of the data.

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[1] Published by Public School Publishing Co., Bloomington, Ill., 1930.

[2] Published by Southern California School Book Depository, Los Angeles, Calif., 1931.

[3] A non-standardized test of 60 items.

[4] Published by C. A. Gregory Co., Cincinnati, Ohio.

What is the relationship between ability in algebra and in geometry? There is one published study, A. L. Rogers,[1] that furnishes data that is comparable with the data in the present study. Dr. Rogers found the correlation between algebraic and geometric ability to be .52 for one school and .38 for another with an average correlation of .47 ± .03. When this average was corrected for attentuation it became .54 ± .02.

Correlations were found between the Lee Test of Algebraic Ability and the Lee Test of Geometric Aptitude for the one hundred eighty-one pupils whose complete records were available. These correlations with the corrections for attenuation are given in Table I.

TABLE I.—THE CORRELATION BETWEEN ABILITY IN ALGEBRA AND ABILITY IN GEOMETRY AS SHOWN BY THE CORRELATION BETWEEN THE LEE TEST OF ALGEBRAIC ABILITY AND THE LEE TEST OF GEOMETRIC APTITUDE

	r(T.A.A.)(T.G.A.)	r(T.A.A.)(T.G.A.) corrected[1]
School *A*	.55 ± .04	.60 ± .04[2]
School *B*	.57 ± .07	.62 ± .07

[1] Kelley, Truman L.: "Statistical Method." New York: Macmillan Co., 1923, p. 204, Formula 155a.

[2] *Ibid.*: P. 209, Formula 161.

From the results of these two studies the conclusion can be drawn that the correlation between ability to do algebra and ability to do geometry probably lies between .50 and .65.

What is the relationship between achievement in algebra and achievement in geometry? Most of the studies in this field have dealt with school marks. The correlation between the final mark in algebra and the final mark in geometry has been found. These studies are summarized in Table II.

In the present study there are two measures of achievement, the marks for the first semester of algebra and geometry and the scores on achievement tests given at the end of the first semester of the respective subjects. These correlations are presented in Table III.

It is interesting to note that in neither school is the correlation as high between achievement tests as it is between marks. *This would*

[1] Rogers, A. L.: Experimental Tests of Mathematical Ability and Their Prognostic Value. *Teachers College Contributions to Education, No.* 89. New York: Teachers College, Columbia University, 1918, pp. 79–80.

seem to indicate an additional factor, separate from achievement, that is influencing the marks.

From a study of Tables II and III, the correlation between achievement in algebra and geometry probably lies between .40 and .70.

TABLE II.—CORRELATIONS BETWEEN ACHIEVEMENT IN ALGEBRA AND ACHIEVEMENT IN GEOMETRY, AS MEASURED BY TEACHERS' MARKS, FROM PREVIOUS STUDIES

Author	No. of cases	Correlations
Burris[1]	16 schools	.57
Crathorne[2]	1900 (approx.)	.52 ± .02
Winegardner[3]	417	.509 ± .024

[1] Burris, W. P.: Correlations of the Abilities Involved in Secondary School Work, Edited by E. L. Thorndike. *Columbia University Contributions to Education*, Vol. XI, No. 2, 1903.

[2] Crathorne, A. R.: "The Theory of Correlation Applied to School Grades," The Reorganization of Mathematics in Secondary Education, Chap. X. The Mathematical Association of America, 1923.

[3] Winegardner, J. H.: The Relation of Success in Mathematics to Success in Physics and Chemistry in High School. *Unpublished Master's thesis*, Department of Education, Stanford University, 1929.

This fact and Table I tends to show that the correlation between ability in algebra and geometry is usually higher than that of achievement, and further, that the correlations between ability are more consistent than those between achievement.

TABLE III.—CORRELATIONS BETWEEN ACHIEVEMENT IN ALGEBRA AND ACHIEVEMENT IN GEOMETRY, AS MEASURED BY TEACHERS' MARKS AND ACHIEVEMENT TESTS

	N	*r* between marks	*r* between tests
School *A*	136	.474 ± .044	.410 ± .048
School *B*	45	.709 ± .050	.566 ± .069

What percentages of pupils show differences between algebra and geometry, in respect to ability and achievement? An attempt to answer this question is another means of attacking the problem of the relationship between these two subjects. The method of finding such differences as called for by the question has been determined by Kelley.[1]

[1] Kelley, Truman L.: A New Method for Determining the Significance of Differences in Intelligence and Achievement Scores. *Journal of Educational Psychology*, Vol. XIV, September, 1923.

The method used is to find the value of $\sigma_{d_{\infty\omega}}/\sigma_d$, then by referring to Table IV in Kelley's article, change this ratio to a percentage. This then gives the percentage of pupils that show differences between algebra and geometry that are more frequent than the chance factors in the measures would produce.

The data and formulae which are needed in this evaluation are as follows:

$$\sigma_{d_{\infty\omega}} = \sqrt{2 - r_{11} - r_{2II}} \qquad \text{(see Kelley[1])}$$

and

$$\sigma_d = \sqrt{2 - 2r_{12}}$$

TABLE IV.—RELIABILITY COEFFICIENTS OF THE VARIOUS TESTS WHICH WERE USED

TESTS	RELIABILITY COEFFICIENTS
Test of Algebraic Ability	.93
Test of Geometric Aptitude	.91
Algebra Achievement Test	.95
Geometry Achievement Test	.85

The other correlation coefficients needed are found in Tables I and III.

The percentage of differences in individual test scores, as shown by the application of the above formulæ and Table IV (Kelley[1]) between algebra and geometry in respect to achievement is forty-one per cent for School A and thirty-four per cent for School B and in respect to ability is forty per cent for School A and thirty-nine per cent for School B. This indicates that there is about as large a percentage of differences found between achievement and also ability tests in algebra and geometry as there is between such tests in the Stanford Achievement Battery, as Arithmetic Computation and Paragraph Meaning.[1]

Using the same technique, differences between the marks in algebra and in geometry were determined. Using .70 as a reliability coefficient for marks and the correlations between marks as given in Table III, the differences were found to be thirteen per cent and zero per cent. If higher reliabilities of marks had been assumed these differences would have been larger, if however, a lower coefficient had been used the differences would have been even less. These differences seem to further indicate there is another factor entering into the marks in

[1] *Ibid.*

both algebra and geometry than those that can be accounted for by achievement or ability.

Are the students who take geometry a more select group than those who take algebra? In answering this question three sets of data will be scrutinized. These are the algebra marks, algebra achievement scores, and the scores on the Lee Test of Algebraic Ability. The records of those pupils for whom both algebra and geometry scores are available will be compared with the algebra records of all the pupils.

First, the algebra marks of the pupils continuing with geometry are compared to the algebra marks given to the whole group. These facts are given in Table V.

TABLE V.—A COMPARISON OF THE MARKS RECEIVED IN FIRST SEMESTER ALGEBRA BY THOSE PUPILS CONTINUING IN GEOMETRY, WITH THOSE RECEIVED BY ALL PUPILS

Algebra marks	Number receiving each mark		Percentage of pupils continuing
	All	Continuing	
A	34	27	79.4
B	125	85	68.0
C	152	65	42.8
D	12	3	25.0
F	71	1	1.4
Total.....	394	181	45.9

In studying Table V, the fact that pupils may have moved, or postponed taking algebra should be considered. The last column shows that 79.4 per cent of the pupils who received "*A*"s in algebra continued with geometry. From this it drops to 68.0 per cent of the "*B*"s continuing. For the "*C*"s it drops to 42.8 per cent then to 25 per cent of the "*D*"s and to 1.4 per cent of the "*F*"s or failures. It is obvious that a much greater percentage of the pupils receiving "*A*"s and "*B*"s continue than do those receiving "*C*"s and "*D*"s. Most students receiving "*D*"s and "*F*"s in algebra consider that they have had all the experience with mathematics courses that they intend to have and therefore do not take geometry.

This condition would seem to indicate that there is a need for careful guidance of the pupils who are to take algebra and the provision of some other course in mathematics for those pupils who will probably

fail or receive "*D*"s. This course should be much easier and cover a much broader mathematical field than the regular algebra course.

Second, the achievement scores of all pupils are compared with those of the pupils who continue with geometry. The records of the two groups are given in Table VI.

TABLE VI.—A COMPARISON OF THE SCORES RECEIVED ON AN ALGEBRAIC ACHIEVEMENT TEST GIVEN AT THE END OF THE FIRST SEMESTER, BY ALL THE PUPILS WITH THOSE OF THE PUPILS WHO CONTINUED WITH GEOMETRY

All Pupils	Continuing Pupils
$M_1 = 25.44$	$M_2 = 29.32$
$\sigma_1 = 9.20$	$\sigma_2 = 7.58$
$\sigma_{M_1} = .46$	$\sigma_{M_2} = .56$
$N = 394$	$N = 181$

It can be seen from an inspection of Table VI that the mean score of the continuing group is 3.88 points higher than the mean made by all the pupils. Does this indicate that there is a real difference between these two groups or is it merely a difference that might be caused by chance? This question can be answered by finding the ratio of the observed difference to the standard deviation of that difference $\left(\frac{M_2 - M_1}{\sigma_{dM}}\right)$. If this ratio is over three, it is fairly certain that there is an actual difference, not a chance difference. The formula used to find the sigma of the differences of the means is:

$$\sigma_{dM} = \sqrt{\sigma^2_{M_1} + \sigma_{M_2}{}^2 - 2r\sigma_{M_1}\sigma_{M_2}}$$

where σ_{M_1} is the σ of the mean of all pupils (see Table VI)
and σ_{M_2} is the σ of the mean of the continuing pupils.

In evaluating the above formula if r is given a value of the σ_{dM} value will be a maximum and $\frac{M_2 - M_1}{\sigma_{dM}}$ is a minimum.

Evaluating

$$\sigma_{dM} = .73 \text{ and } M_2 - M_1 = 3.88,$$

hence

$$\frac{M_2 - M_1}{\sigma_{dM}} = 5.35$$

Since the ratio of the observed difference to the standard deviation of that difference is 5.35, it is certain that the difference is real as far as achievement in algebra is concerned and that the pupils continuing with geometry were superior in achievement to the group as a whole.

Third, the scores of all the pupils on the Lee Test of Algebraic Ability are compared with those of the pupils continuing with geometry. The same method of comparison is used for the ability scores as is used for the achievement scores. The records of the two groups on the ability test are given in Table VII.

TABLE VII.—A COMPARISON OF THE SCORES RECEIVED ON THE LEE TEST OF ALGEBRAIC ABILITY BY THOSE PUPILS CONTINUING IN GEOMETRY WITH THOSE OF ALL PUPILS

ALL PUPILS	CONTINUING PUPILS
$M_1 = 81.63$	$M_2 = 92.94$
$\sigma_1 = 24.63$	$\sigma_2 = 21.81$
$\sigma_{M_1} = 1.24$	$\sigma_{M_2} = 1.62$
$N = 394$	$N = 181$

It can be seen from Table VII, that the mean score of the group that continued with geometry is 11.32 points higher than the mean of all the pupils. Evaluating this difference—

$$\text{Assuming } r = 0, \text{ then } \sigma_{dM} = 2.04, \text{ and } \frac{M_2 - M_1}{\sigma_{dM}} = 5.55.$$

Since this ratio is equal to 5.55 it is certain that the difference was real as far as ability to do algebra, as measured by the Lee Test of Algebraic Ability is concerned and that pupils continuing with geometry were superior in algebraic ability to the group as a whole.

The three sets of data, marks and achievement record in first semester algebra and the scores on the ability test all tend to prove that the group that continued with geometry were a select group as compared with the total group that took algebra. The poorer students, academically speaking, do not continue with their mathematics. If by careful educational guidance we would place the pupil where he belonged in the first place, instead of letting him find it by trial and error, what a large amount of time, money, and discouragement could be saved.

Do students tend to get better or poorer grades in geometry than in algebra? One means of answering this question is from an inspection of the scattergrams between marks in algebra and in geometry.

Chart 1 shows that pupils tended to get poorer grades in geometry more often than they got better ones as compared with their grade in algebra.

It is interesting to note that only one pupil raised his mark as much as two points. This pupil in School A received a C in algebra and an

A in geometry. His ability test in algebra showed he was quite low but in geometry his ability score went up to the 75th percentile of the group. His achievement tests agreed with the marks, in fact, all records indicated that he was only low average in algebra and superior in geometry. He is the best example of marked differences favoring geometry that is in the study.

CHART I.—A COMPARISON BETWEEN MARKS RECEIVED IN GEOMETRY WITH THOSE RECEIVED IN ALGEBRA

School A

Algebra \ Geometry	F	D	C	B	A	
A		1	1	9	**7**	18
B	2	8	17	**25**	11	63
C	9	13	**18**	13	1	54
D			1			1
F						
	11	23	36	47	19	136

School B

Algebra \ Geometry	F	D	C	B	A	
A			1	4	**4**	9
B		3	14	**3**	2	22
C	2	5	**3**	1		11
D		**2**				2
F	**1**					1
	3	10	18	8	6	45

The figures in bold face type indicate the pupils that received the same mark in both subjects. Those above this diagonal line received a lower mark while those below it received a higher mark. In School A, fifty pupils received the same mark, twenty-six improved their mark while sixty lowered it. This situation is to be expected since in the case of algebra these pupils were a select group in the upper ranges, but in geometry these same cases were redistributed over a normal distribution. It would then be expected that the chances for a pupil to get a lower mark in geometry are greater than his chances to get a higher mark. In School A, this chance of getting a lower mark was a little over two to one, while in School B it was nearly ten to one.

Another comparison between algebra and geometry that is worth noting is the differences in the percentage of each mark given. Taking the two school systems that were used in both studies, percentages of each mark given are compared in Table VIII.

There is a slightly greater per cent of "*A*"s given in geometry, however the outstanding difference is in the percentage of "*D*"s. This might be accounted for by the fact that algebra is much more

definite and the failing point can be determined with more ease than in the case of geometry.

TABLE VIII.—A COMPARISON OF THE NUMBER AND PERCENTAGE OF EACH MARK GIVEN IN ALGEBRA AND GEOMETRY

Mark	Algebra		Geometry	
	Number	Per cent	Number	Per cent
A	34	8.6	38	12.2
B	125	31.7	98	31.4
C	152	38.6	90	28.9
D	12	3.0	51	16.3
F	71	18.0	35	11.2
Total.....	394	99.9	312	100.0

SUMMARY

Comparisons made between algebra and geometry using marks, achievement test scores, and ability test scores have led to the following conclusions:

1. The relation between ability to do algebra and ability to do geometry as expressed by correlation coefficients, probably lies between .50 and .65.

2. The correlation between achievement in algebra and geometry probably lies between .40 and .70.

3. The correlations between ability in algebra and geometry are usually higher and more consistent than those of achievement.

4. About 40 per cent of the pupils show differences between algebra and geometry in respect to both ability and achievement that can not be attributed to chance.

5. Some factor other than ability and achievement is entering into school marks in these two subjects.

6. Students who take geometry are a select part of the group that took algebra the year before.

7. Pupils receiving low marks in algebra do not as a rule take geometry.

8. Pupils have a greater chance in geometry of getting a mark lower, rather than higher, than they got in algebra.

9. It seems that it is more difficult to determine the failing point for a pupil in geometry than it is in algebra.

The educational implications of the above findings seem to be:

1. Better guidance of a pupil in geometry is possible by using tests of ability to do geometry than by using the algebra record. The two however should be used together.

2. More careful educational guidance should be given pupils who are ready to enroll in algebra, and the probable failures eliminated. A course should be provided for these pupils which is much easier and covers as broad a mathematical field as possible.

3. Marks should be given on the basis of achievement. In order to eliminate other factors which are now determining the mark, such objective measures of achievement as are now obtainable should be used. These objective tests should be given several times throughout the semester to give as many measures as is possible.